The Engineer

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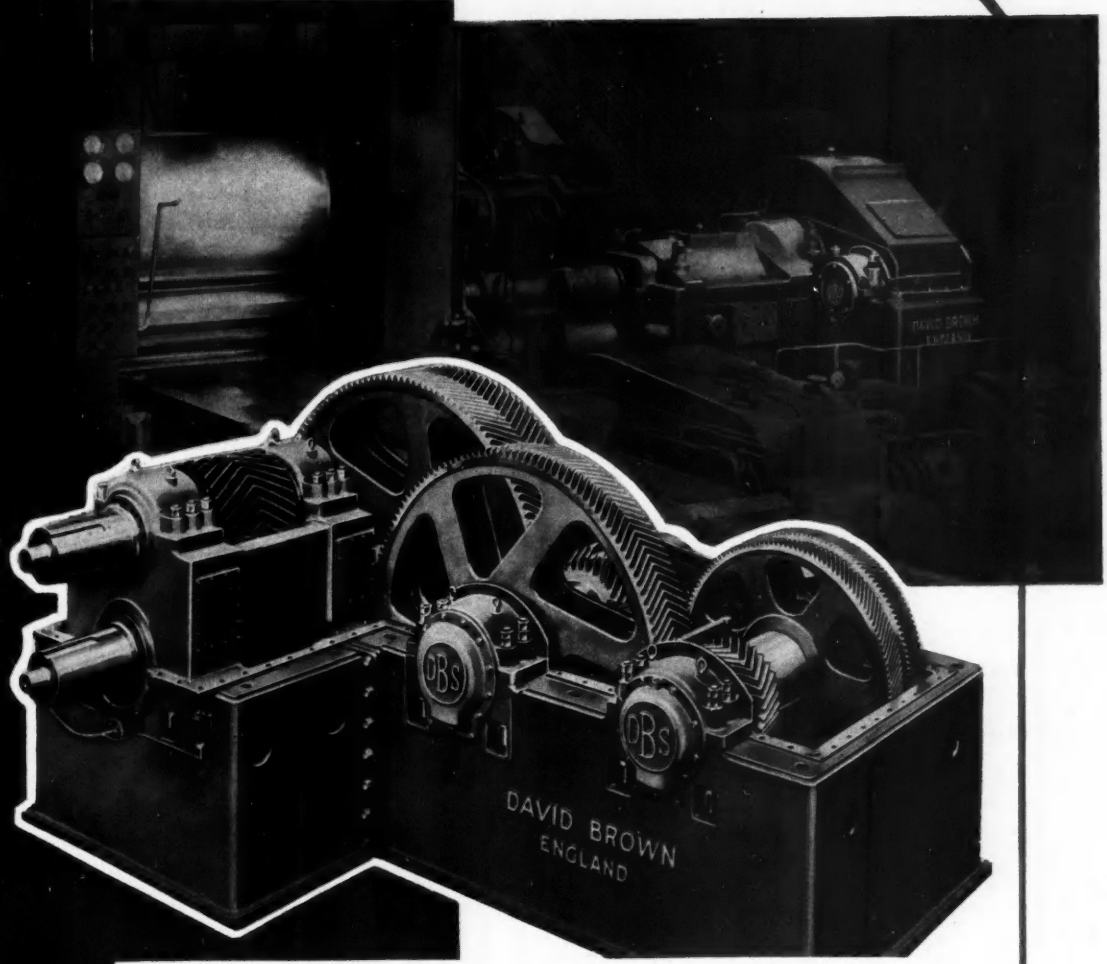

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THE ENGINEER

FEBRUARY 4, 1955

"Olympus" and "Proteus" Engines

LAST Tuesday we were invited to see the "Olympus 101" turbo-jet aircraft on the test bed at the Filton works of the Bristol Aeroplane Company, Ltd. This engine has now passed a 150-hour type test at 11,000 lb static thrust and is believed to be the most powerful engine at this particular stage of development outside Russia. The engine has a coaxial rotor system, in which two compressors in series are driven each by a separate turbine with no mechanical coupling between them. The first (low pressure) compressor feeds the second (high pressure) compressor so that each can run at its optimum speed. The main advantages claimed for the two-spool design, which has been pioneered by the Bristol Aeroplane Company, are its low fuel consumption over a wider range of altitudes; better maintenance of power at great altitudes; easy starting and handling and extremely rapid acceleration. It is maintained that they easily justify the greater mechanical complexity of the system, especially in larger engines, which at the moment leads to an engine of greater specific weight than the single shaft layout. The "Olympus" has a specific fuel consumption of 0·79 lb/lb thrust/hr., which is achieved by reason of its higher compression ratio and gas temperature. The influence of these factors was discussed by the chief designer during our visit, and it was shown that by working with a compression ratio of, say, 10 : 1 and an air turbine inlet temperature of 1100 deg. K. a 25 per cent reduction in specific fuel consumption can be obtained when compared with that obtained with the early single-shaft engines of 4 : 1 ratio. The company also referred to its turbo propeller engine, the "Proteus," and to "Britannia" progress. Production of this engine—the only engine in power categories over 2000 s.h.p. to possess a C. of A. classification—is now running at sixteen a month. Elsewhere in this issue we have referred to the immediate policy of two other engine manufacturers with respect to equipping new and converted aircraft with turbo propeller engines. The Bristol Aeroplane Company, Ltd., maintains that the conversion of existing airframes requires fairly extensive wing and fuselage modifications, and that such a machine would not be significantly quicker or cheaper to produce than a new airframe. It was confident that no American machine of which such a conversion or development mark could be envisaged would compare with the performance or delivery dates of the "Britannia" series of aircraft.

Institution of Mining Engineers

AT the annual luncheon of the Institution of Mining Engineers, which was held in London on Thursday of last week, the president, Major N. E. Webster, presented the medal of the institution to Sir Andrew Bryan. Speaking at the luncheon, Major Webster drew attention to a fact which, he said, was not fully appreciated—that the total production of coal was less to-day because of the ever-increasing number of men employed in making coal mines safer and healthier places in which to work. As a result of this work, British mines were now in many respects the safest in the world, and the policy of safety being followed would pay in due season not only by the reduction of the accident rate but also in reducing the all too high wastage of manpower. In his speech which followed, Sir Andrew Bryan dealt at some length with the work of the professional mining engineer. He maintained that highly skilled mining engineers should apply their existing knowledge and resources far more effectively and not by thinking up new methods or formulæ. To do this they should make more use of subordinates. He said that there were men with First Class Certificates of Competency in mine management, who, as colliery managers, were doing tasks many of which were really the job of the overman. In other words professional men were undertaking, without much objection, the performance of tasks which were well below their technical competence when the mining industry was short of thinking power. This was the fault of the profession itself in its tendency to place too narrow an interpretation of what it meant when professional mining engineers called themselves "practical men." New ideas were not easily digested and figures or statistics were too readily discarded for the immediate practical approach of coal getting, when planning was required and difficulties and problems discussed. Sir Andrew went on to say that it was not the business of mining engineers to do the jobs of under-officials and workmen, but rather it was up to them to see that the men and under-officials had the best resources with which to carry out their jobs.

Clean Air Bill

TO-DAY, the Clean Air Bill, which has been presented by Mr. Gerald Nabarro, is being given a second reading in the House of Commons. The main provisions of the Bill are to confer powers on local authorities to establish smokeless zones and smoke control areas, and to require the use of approved kinds of industrial furnaces and ancillary plant and domestic heating appliances and, generally, for securing the abatement of atmospheric pollution and smoke. The Bill thus seeks to implement the principal recommendations of the final report of the Beaver Committee on air pollution, with the exception of those recommendations entailing fiscal changes and those within the powers of direction which are exercisable by Ministers under the nationalisation statutes. It may be recalled that the Beaver committee's report made twelve specific recommendations entailing legislation, and in the present Bill it is proposed that eight of those recommendations shall be implemented. One clause in the Bill, therefore, provides that no person shall install any furnace for manufacturing or trading purposes unless it is capable of being operated continuously without emitting dark smoke. Another provision which is sought is that no person shall install any furnace for manufacturing or trade purposes which is designed to burn pulverised or solid fuel at a rate exceeding 10 tons an hour unless it is provided with effective and approved grit-arresting plant. There is also a clause which provides that, after the expiration of three years from the passage of the Bill, any emission of dark smoke from the chimney of any manufacturing or trade premises shall be an offence, "subject to certain exceptions." Finally, the Bill provides that it shall be the duty of a local authority to enforce the law relating to the abatement of smoke and atmospheric pollution within its district, and to publish annual reports on the progress made.

Air Pollution Legislation

AT a meeting of the Royal Sanitary Institute, which was held in London on Wednesday of last week, Sir Hugh Beaver spoke about some of the administrative problems associated with air pollution legislation. He said that nothing but a comprehensive Government Bill could fully meet all the objectives sought in his committee's report, and added that existing legislation and powers concerning air pollution "were wholly inadequate and quite illusory." The best that could be made of existing legislation was quite insufficient, Sir Hugh continued, but the effective administration by local authorities of existing or proposed air pollution legislation depended upon officials with the right knowledge, experience and time to perform their duties. Sir Hugh went on to say that a heavy responsibility would be placed on local authorities if anything like the recommendations of his committee's report in regard to smokeless zones and smoke control areas were accepted. It would be a detailed time-consuming matter, as each combustion unit on every building would have to be examined before the practicable boundary of the proposed zone could be drawn. Sir Hugh also spoke about the 1500 or so smoke measuring recorders which were in operation in the United Kingdom, from which the Fuel Research Station received 100,000 reports each year. He felt that there was a danger of important research work being submerged by the routine of dealing with reports, which, he suggested, could be done at local level.

Retirement of Mr. J. I. Campbell

AT the end of last month Mr. J. I. Campbell retired from his post as chief civil engineer of the Eastern Region of British Railways. Mr. Campbell joined the staff of the District Engineer's Office (Northern District) of the Caledonian Railway at Perth in 1907 under Mr. D. A. Matheson, who was then chief engineer. He became junior assistant in the district office at Edinburgh and early in 1914 entered the chief engineer's office of the North British Railway as an assistant. During the first world war he served with the Army, and was commissioned in the Royal Engineers in 1917. On demobilisation Mr. Campbell returned to the North British Railway in the new works section and remained there after the grouping in 1923 until January, 1930, when he became assistant district engineer, Guide Bridge, L.N.E.R. In 1937 he was appointed district engineer, Boston, and two years later moved to London as assistant to the engineer (general), Southern Area. In 1947 he became engineer (Southern Area), L.N.E.R. and on nationalisation in 1948 he was appointed civil engineer of the Eastern Region, the post being re-titled chief civil engineer on January 1st last. During his career Mr. Campbell has been associated with many railway engineering works of importance, including the civil engineering work necessitated by the Liverpool Street-Shenfield and Manchester-Sheffield-Wath lines electrification, the Thurgoland New Tunnel, the reconstruction of Ipswich locomotive depot, Potters Bar station, and finally the construction of Woodhead New Tunnel, opened last summer.

Report of the Chief Inspector of Mines for 1952

THE annual report of the Chief Inspector of Mines for the year 1952 states that the number of persons killed in that year was 420, a new low record when compared with previous years. The number of persons reported to have been injured from all causes was 2109, an increase of 167 on the previous year. As a result of this increase the total number of persons killed and injured rose from 2429 in 1951 to 2529 in 1952. The accidents not immediately reportable, but causing disablement for more than three days, increased from 234,400 in 1951 to 238,100 in 1952, but, due to the increase in the number of persons employed in mines, there was little change in the rate compared with the previous year. The report points out that the incidence of the minor accidents was affected by factors other than those influencing the rate of serious accidents and fails to reflect the very material improvements in mining conditions that have taken place over the last decade, during which fatal accidents have fallen by 52 per cent and non-fatal by 25 per cent. In connection with the mines inspectorate the report shows that it has not been possible to recruit a sufficient number of suitable mining engineers, and that in 1952 there existed a deficiency of 20 per cent of the authorised establishment.

Improving Locomotive Performance

RECENT TRIALS WITH THE E. AND N.E. REGION "V2" CLASS

By O. S. NOCK

Modern testing practice on British Railways is being applied to the enhancement of locomotive capacity, by rendering engines of pre-war design capable of work under the difficult circumstances of to-day. In this article the author comments upon tests carried out at Swindon with a Gresley "V2" engine

THE three-cylinder 2–6–2 mixed traffic locomotives of the "V2," or "Green Arrow" class were among the most versatile of the "big-engine" designs prepared by the late Sir Nigel Gresley. Prior to the introduction of the "V2" in 1937 the express freight services of the former London and North Eastern Railway, giving one-day transits between important towns, were run mostly by three-cylinder 2–6–0 locomotives of the "K3" class; the latter were excellent engines of their kind, but were becoming small for the increasing demands of tighter schedules and heavier loads. North of York it was possible to arrange the workings so that express passenger "Pacific" engines were available for some of the hardest express freight duties; but over the old Great Northern line, where there were timings like that of the 3.35 p.m. Scotch Goods from King's Cross, it was not possible to do this, and "K3" engines had to be relied on for the job. This train with a daily load of about 600 tons was booked to cover the 111¾ miles from Westwood Yard, Peterborough, to Severus Junction at York in 149 min, an average speed of 45 m.p.h. It was, in particular, for duties such as this that the new 2–6–2 mixed traffic engine was introduced. The salient characteristics of the design may be appreciated by the accompanying Table I, showing the leading dimensions, in comparison with those of the "K3" 2–6–0 and of the "A3" express passenger "Pacifics."

Fig. 1—Controlled mobile road test. Engine No. 60845, "V2" class, near Swindon, with twenty-six coach test train

While a leading pony truck may not be considered ideal for high-speed running, the quality of permanent way on the London and North Eastern main line was then outstandingly good; the new mixed traffic engines, in common with Sir Nigel Gresley's "Pacifics," proved to be very steady in riding, and before they had been in service two years one saw them regularly employed on some of the fastest of the ordinary expresses running south of Doncaster. In emergency they were even put on to the high-speed streamlined trains. In heavy and fast freight service, as might be imagined, they proved admirable and, after the outbreak of war in 1939, construction of them continued steadily. On the decelerated main line passenger service between King's Cross and Aberdeen the 2–6–2s worked turn and turn about, indiscriminately, with three varieties of Gresley "Pacifics," and the relatively slow schedule times of the war period were kept by "V2" engines with loads sometimes exceeding 800 tons. Like the Gresley "Pacifics," they showed a remarkable capacity for sustained hard steaming, though there were naturally times when the quality of the coal supplied proved too much and then time was lost. Some examples of working under various conditions are given in Table II.

TABLE I

Engine:	"K3"	"V2"	"A3"
Class			
Type	2–6–0	2–6–2	4–6–2
Cylinders (3):			
Diameter	18½in	18½in	19in
Stroke	26in	26in	26in
Coupled wheel diameter ...	5ft 8in	6ft 2in	6ft 8in
Total heating surface, square feet	2,308	3,110·7	3,395
Grate area, square feet ...	28	41·25	41·25
Boiler pressure, pounds per square inch	180	220	220
Total weight in working order, tons	72·6	93·1	96·25
Nominal tractive effort at 85 per cent boiler pressure, lb	30,031	33,730	32,909
Factor of adhesion	4·53	4·3	4·61

During the war years the utilisation of the class as a whole was high, and at depots such as Grantham, York and the Newcastle sheds of Gateshead and Heaton there were periods when no definite rostering was possible and engines were allocated to duties on the "first-in, first out" principle. While the reduced standards of maintenance resulted in some failures of the conjugated valve motion for the inside cylinder, the steaming was generally reliable except when overwhelming handicaps such as blocked tubes or coal with a high "dirt" content prevailed. After the war, to reduce the time spent on

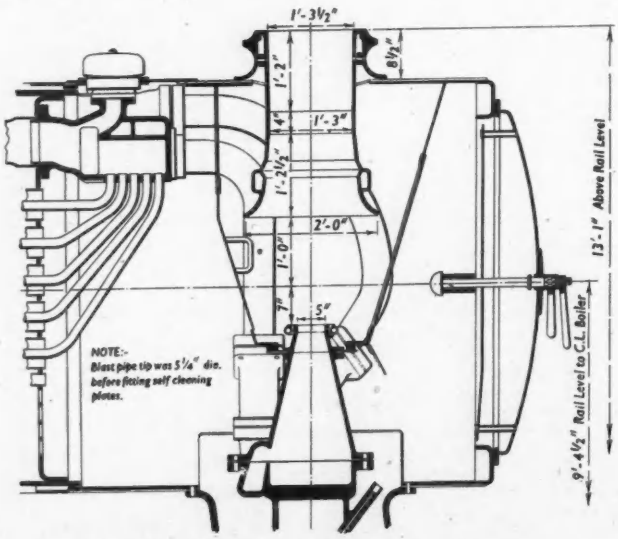


Fig. 2—Original arrangement of smoke box

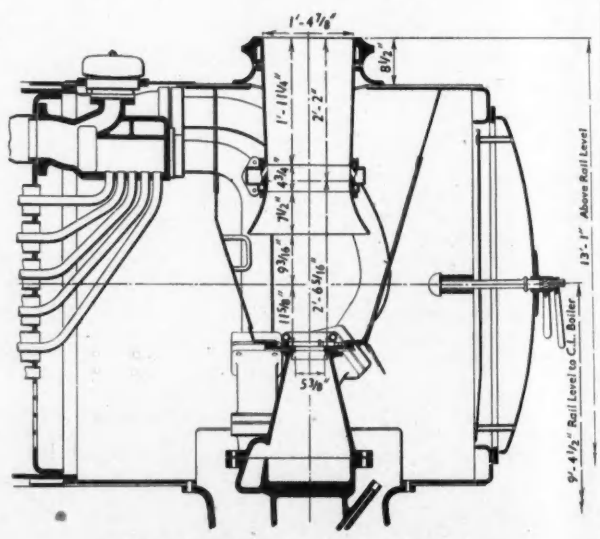


Fig. 3—Smoke box arrangement as modified

shed and assist towards good utilisation, self-cleaning plates were fitted in the smokebox; this had a markedly adverse effect upon the steaming. Various trial alterations were made to the dimensions of the blast-pipe and chimney, with little or no effect, save that the final reduction in orifice diameter from the original 5¼in to 5in could hardly fail to increase coal consumption and impair the free-running characteristics that had been such a notable feature of the original design. It had been noted elsewhere that the fitting of self-cleaning plates to the smokeboxes of three-cylinder, as distinct from two-cylinder engines, had had an adverse effect, and so it was decided to send a representative engine of the "V2" class to the Swindon test plant for investigation.

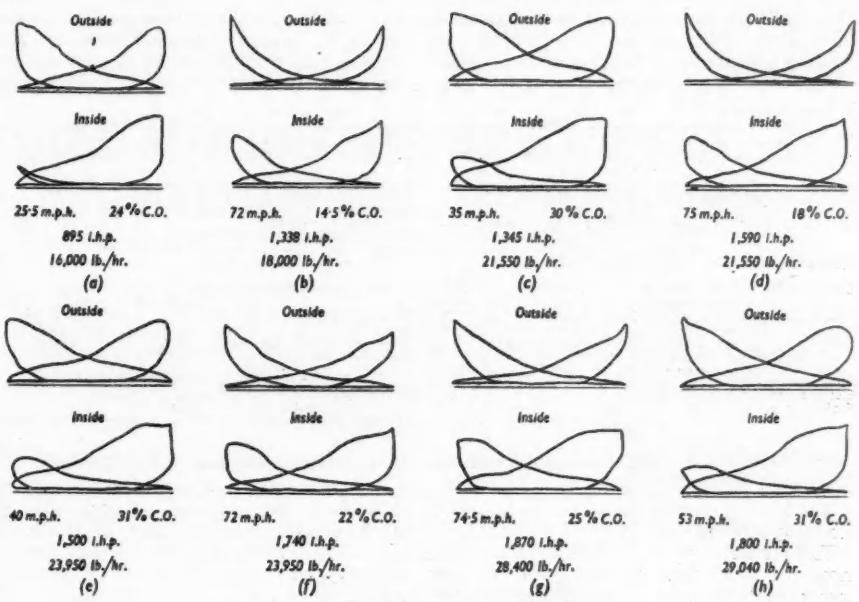
The results are now embodied in a bulletin issued by the British Transport Commission, and they are of special interest on two accounts: they reveal the details of relatively simple and cheap modifications made to the draughting to render the steaming satisfactory, and they show for the first time full thermodynamic test results on a locomotive of the generic Gresley three-cylinder engine design, in conjunction with a large boiler and Wootton type wide firebox. In the past various results from "Pacific" engines have been quoted; but these tests were all made on service trains in varying conditions of steaming. The analytical results obtained from the Swindon test plant, and from controlled road tests between Reading and Stoke Gifford, have now established the full performance of the class.

The locomotive received at Swindon for testing, No. 60845, had not long previously received general overhaul. Its mileage since that overhaul was 4252 miles. Trouble was at first experienced with hot boxes because of slight misalignment of the engine wheels with respect to the rollers of the plant. This caused continuous pressure between wheel bosses and box faces on one side, and prevented oil from the bearings from reaching these rubbing surfaces. This trouble so interfered with testing that the engine was returned to the owning Region to have positive oiling arrangements provided to these rubbing surfaces. Another difficulty arose from the use of "Pop" safety valves. On all locomotives of Great Western design it has long been traditional to run as far as possible with the safety valves at "sizzling" point; with direct loaded valves this can readily be done, and boiler pressure kept at a very even figure. On the "V2," however, with the safety valves lifting at 225 lb per square inch, and not closing until the pressure had fallen to 205 lb, steam was discharged in such volume as to fill the plant and make testing not only difficult, but at times hazardous. The pressure had therefore to be kept below blowing-off point while working on the plant, though the maintenance of an even pressure at about 215 lb per square inch in all probability gave better overall results than if pressure had see-sawed with periods of blowing off intermediately.

TABLE II

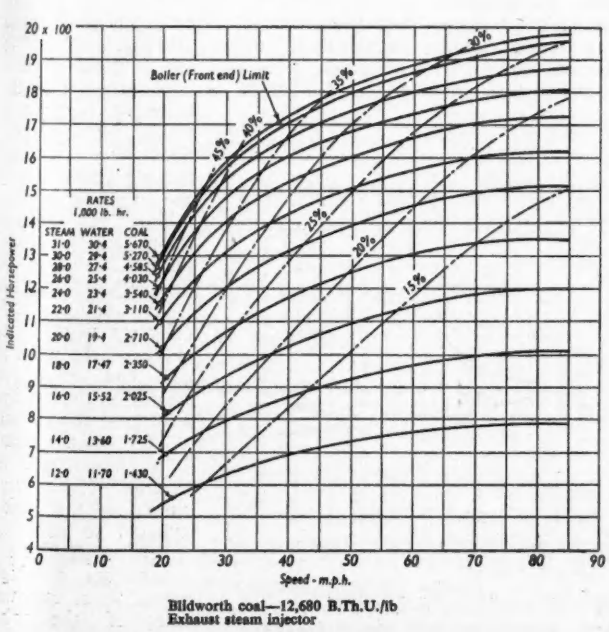
Run	Engine No.	Load, tons	Distance, miles	Actual time, minutes	Net time, minutes	Average speed, net m.p.h.	Maximum speed, m.p.h.
Doncaster–King's Cross	4817*	380	156	151¾	147½	63½	93
Woodford–Leicester	4830*	255	34	30	30	68	88
York–Darlington...	60960	460	44	48¼	44½	59½	80
Grantham–York	60853	345	82½	85¼	81	63½	78
King's Cross–Grantham	60983	485	105½	120¼	116½	54½	85½
Grantham–King's Cross	60903	480	105½	116	109	58	83½

* Original numbering.



Mean steam rates in lb per hour with full regulator

Fig. 5—Examples of indicator diagrams



Bildworth coal—12,680 B.Th.U./lb
Exhaust steam injector

Fig. 4—Indicated horsepower characteristics after modification

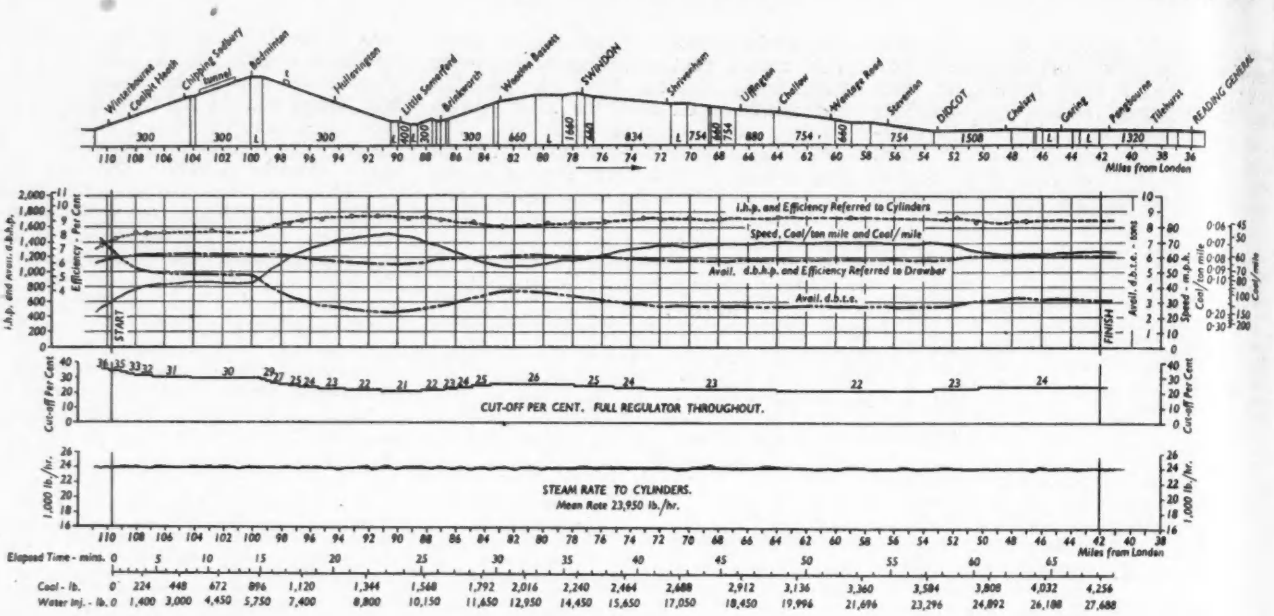
As received for testing the engine had smokebox arrangements as shown in Fig. 2. This was the same as the original design of 1937, except that the self-cleaning plates had been added, and the blast pipe orifice was reduced from 5¼in to 5in. As received, the engine steamed poorly. She was fired throughout on Blidworth coal, but the air supply was insufficient to maintain continuously a rate of evaporation higher than 14,000 lb per hour. This amply confirmed the bad reputation these engines had been acquiring in service since the fitting of self-cleaning plates: removal of the plates without any other alteration enabled the maximum rate of evaporation to be raised to 24,000 lb per hour. A steam rate of this magnitude corresponded roughly to some of the best road performances of the class in pre-war service, but the emission of black smoke in considerable quantities showed clearly that the combustion was not complete. The principles of smokebox design, as embodied in several locomotives from other Regions as a result of examinations on the Swindon test plant, were applied to this engine, and the chimney and blast pipe were modified as in Fig. 3. The results were remarkable and may be tabulated as follows (Table III).

TABLE III

Description	Self-cleaning plates	Diameter of blast nozzle	Maximum steam rate, lb/hr	Increase over first state
As received	In	5in	14,000	—
As received	Out	5in	24,000	71·5%
Modified draughting	In	5¾in	31,000	121%

The final result, which, like the earlier ones, was attained by Blidworth coal, is the more interesting in that the emission of black smoke was completely cured. Having established this high maximum steam rate, the locomotive was put through a complete series of analytical trials, on the stationary plant and on the road.

In view of the very great improvement in steaming made as a result of the draughting alterations, the details presented in Table IV are of interest, as showing the actual changes in dimensions that were made.



Mean steam and water rates, lb/hr.	Actual	Equiv. at 212 deg. Fah.
Cylinder steam	23,950	33,400
Ejector steam ...	400	488
Total	24,350	33,888

Temps. deg. Fah.	
Admission steam ...	690
Ejector steam	385
Feed water	44

Mean coal rates, lb/hr.	
Evap. of cylinder steam	36·5
Ejector steam	55
Total	3750
Lb/sq. ft grate/hr. ...	91
Boiler efficiency—per cent	69–6

Testing unit—W.R. dynamometer car
Blidworth coal of 12,600 B.Th.U. per lb as fired.
Live steam injector only
Load 761·7 tons (twenty-five coaches)
Natural wind : Velocity—low and indeterminate
Direction—random

Average consumptions in pounds

	Inclusive	Net, for power
Coal per avail. d.b.h.p. hr ...	3·175	3·125
Coal per i.h.p. hr	2·26	2·225
Water per avail: d.b.h.p. hr ...	20·6	20·25
Water per i.h.p. hr	14·68	14·43

Adjustment for exhaust steam injector :—
Reduce feed water consumption by 2·46 per cent
Reduce coal consumption by 3·74 per cent
Multiply efficiency and divide coal per ton mile and coal per mile by 1·037

Fig. 6—Controlled road test with twenty-five coach train

The leading dimensions of the locomotive, for ready reference, are as given in Table V.

The results from the stationary plant and from the road tests were analysed and co-ordinated in the manner described so comprehensively in Mr. S. O. Ell's paper to the Institution of Locomotive Engineers on November 18, 1953, to which reference was made in THE ENGINEER for February 5 and 12, 1954. There is, of course, a natural and

TABLE IV—*Draughting Arrangements*
(In each case with self-cleaning plates in)

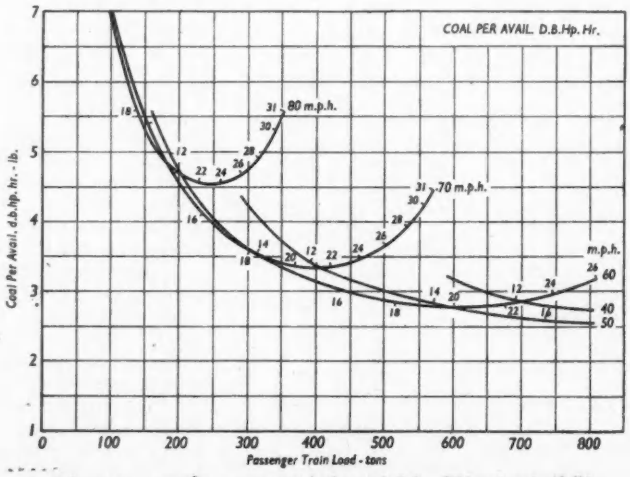
	Before modification	After modification
Blast pipe orifice :		
Diameter, inches	5	5·375
Area, square inches...	19·63	22·7
Chimney :		
Diameter at choke, inches	15	15
Area at choke, square inches ...	176·7	176·7
Diameter at top, inches...	15·5	16·875
Chimney bell, diameter at bottom, inches	24	21·8
Blast pipe orifice, below smokebox centre line, inches	7	11·625
Chimney choke above blast pipe orifice, inches	33·5	30·31
Height of chimney, choke to top, inches	18	26
Chimney sides, taper	1 in 28	1 in 14
Chimney bell, depth below choke, inches	14·5	9·5
Chimney choke diameter ...	3	2·79
Blast pipe orifice diameter		
Height of choke above orifice diameter of choke ...	2·23	2·02
Height of bottom of bell above orifice diameter of choke	1·27	1·39
Maximum evaporation, pounds of steam per hour	14,000	31,000

almost irresistible temptation to compare test results obtained with different types of locomotives, especially when they are obtained by the same team of engineers working under closely comparable conditions, and when the data are subjected afterwards to so strictly disciplined an analysis. But while comparisons may enter these comments one of the most important aspects of modern locomotive testing is the data it provides for the timing of trains, in which bed-rock facts of haulage capacity are of much greater moment than a fractional advantage here or there in thermodynamic efficiency. For, as Mr. E. S. Cox pointed out in his paper covering experiences with the new British Standard locomotives, the variations in efficiency between the different designs of modern locomotives on British Railways are now relatively small. Nevertheless there are some points of interest that arise in comparing tests of locomotives of the Swindon and Doncaster "schools," now that the individuality of both seems at an end.

As with the "King," so with the "V2" the limit of evaporation was determined by the front end, at a water rate of 30,400 lb per hour, a steam rate of 31,000 lb and a coal rate of 5670 lb using Blidworth coal. This latter was equivalent to 138 lb per square foot of grate area per hour. The indicated horsepower characteristics are shown in Fig. 4, though in studying this diagram the values of cut-off quoted must be regarded as nominal only. The Gresley conjugated valve motion to the inside cylinder gave a most uneven distribution of steam, especially at low speeds, and a series of typical indicator diagrams are reproduced in Fig. 5 to show this characteristic. From a set of diagrams such as those marked (*a*) in Fig. 5, at 16,000 lb per hour steam rate and a speed of 25·5 m.p.h. one might perhaps expect that the indicated horsepower would be comparatively low ; in actual fact it is almost exactly the same as that of the "King" at the same steam rate and speed, though the fact of the inside cylinder of the "V2" doing practically the whole of its share of the work at one end results in strains on the motion, a surging action, and a very uneven beat. It is endeavoured to arrange the valve timing of the inside cylinder to eliminate as far as possible the inequalities at high speed when overrunning of the valve spindle is most pro-

TABLE V—*Dimensions of "V2" Engine*

Boiler :	
Tubes, small :	
Number	121
Outside diameter	2¼in
Superheater flues :	
Number	43
Outside diameter	5⅛in
Superheater elements	43
Outside diameter	1·244in
Heating surfaces :	
Firebox...	215 sq ft
Tubes	1211·7 sq ft
Flues	1004·3 sq ft
Total evaporative	2431 sq ft
Superheater	679·7 sq ft
Total	3110·7 sq ft
Grate area	41·25 sq ft
Boiler pressure	220 lb/sq in
Coupled wheels, diameter	6ft 2in
Cylinders :	
Three, diameter and stroke	18½ × 26in
Motion :	
Piston valves, diameter	9in
Maximum valve travel	5⅛in
Steam lap :	
Inside cylinder	1 1/16in
Outside cylinder	1⅛in
Cut-off in full gear, per cent	65
Tractive effort at 85 per cent boiler pressure ...	33,730 lb



Small figures on curves refer to steam rates in thousands lb/hr. Blidworth coal—12,680 B.Th.U./lb Exhaust steam injector

Fig. 7—Passenger service-level. Examples of cost in coal of different train loads and speeds

nounced, and the dangers of failure are at their greatest. The high-speed diagrams (*b*), (*d*), (*f*) and (*g*) in Fig. 4 show, however, that while there is a better distribution of steam in the central cylinder itself that cylinder is doing an altogether inordinate share of the total work.

Reverting to the diagram (Fig. 4), the curves for each steam rate show the i.h.p. rising to its maximum at approximately 85 m.p.h. The readiness with which these engines will run up to that speed in ordinary service is a further tribute to their freedom at the front end, despite the inequalities in the steam distribution. The Swindon tests show what can be done with a well-tuned engine, but in general service the " V2 " class is employed almost entirely on common-user duty, and many locomotives that one notes are " off their beat " to an extent far greater than No. 60845, as represented in the trials. On a certain evening in the past summer a " V2 " was used in emergency to work the Tees-Tyne Pullman express northwards from York, with a load of 323 tons tare behind the tender. The timing is fast, with an allowance of 41 min start to stop for the 44 miles from York to Darlington, and although the engine was much off her beat the driver hammered her along, hard. Having taken over the train at Grantham, the engine was thoroughly warmed up by the time York was left ; yet while the accelerative qualities of No. 60845 on test at Swindon were good, the sister engine on the Pullman train was very sluggish in getting away. After that she was flogged, on a nominal cut-off of 25 per cent, to make an average speed of 76 m.p.h. over the faintly rising stretch from Raskelf to Danby Wiske. The firing was expert and the boiler free-steaming, yet the steam distribution was all the time putting a low limit on the capacity of the engine.

While at Swindon No. 60845 was put through a series of controlled road tests culminating in a spectacular run with a twenty-five-coach train, details of which are shown in Fig. 6. The test train is illustrated in Fig. 1. It is interesting to compare this with that of the " King " class engine, to which reference was made in THE ENGINEER February 12, 1954, and some comparative details are given below in Table VI.

TABLE VI—*Heavy Load Runs : Controlled Road Tests*

Engine	" V2 "	" King "
Load, tons	762	781
Steam rate, pounds per hour	23,950	28,700
Average speed (m.p.h.), Badminton–Steventon stage	64·6	68·5
Coal	Blidworth	Markham
Calorific value, B.Th.U. per pound	12,600	14,510
Coal per drawbar horsepower-hour*	3·07	3·00
Boiler efficiency, per cent	69·6	63

* Including adjustment for exhaust steam injector.

The only noticeable difference between the two locomotives in these tests lies in the boiler efficiency, and that is wholly attributable to the difference in steam rate. At a steam rate of 28,700 lb per hour the " V2 " shows a boiler efficiency of about 62 per cent, while conversely the " King " would undoubtedly show a lower basic coal consumption at a lower steam rate.

One of the more marked characteristics of performance brought out by this test bulletin is the heavy increase in coal consumption at high speed. This is shown first in Fig. 7, which reveals that in running at 80 m.p.h. on the level the coal per available d.h.p. is at a minimum of 4·55 lb with a 250-ton train and rises to 5·5 lb with a 350-ton train. At such speeds, of course, the proportion of the power developed in the cylinders that is utilised for hauling the train is relatively low, and at a steam rate of 23,000 lb per hour, which corresponds to the haulage of a 250-ton train at 80 m.p.h. on level track, the coal consumption per i.h.p. hour with a " V2 " is 2·0 lb, or 3325 lb of coal fired per hour.

As discussed in commentaries upon previous bulletins, a firing rate of 3000 lb per hour is considered the maximum practicable

TABLE VII—*Firing Rate 3000 lb Blidworth coal per hour*

Speed (m.p.h.)	Load, tons, level track	Load, tons, 1 in 200 rising gradient
30	—	775
40	—	550
50	—	370
60	660	250
70	410	140
80	220	—

with hand firing, and on the " V2," using Blidworth coal, the boiler evaporates 20,900 of cold feed per hour into steam at normal boiler pressure and at 680 deg. Fah. The boiler efficiency is then 73 per cent. With the exhaust injector in use the cylinders can be supplied continuously with 21,500 lb of steam per hour. Table VII gives the loads that may be hauled at sustained speeds as quoted, on level track and on a rising gradient of 1 in 200 in these steaming conditions.

Although the " V2 " is regarded as a mixed traffic locomotive the above analysis shows that, if the mechanical condition of the engine is satisfactory, it is quite a practical proposition to use engines of this class on high-speed trains in emergency. With Grade 1A coal, such as the best hard Yorkshire varieties, the conditions should, theoretically, be still more favourable ; though the author has known cases where the firing rate was definitely limited by the extent to which a fireman had to break the large lumps loaded on to the tender into suitable sizes for firing. In the Swindon trials, of course, where coal rates up to 5600 lb per hour were attained, two firemen were carried, and the coal was supplied to them in the usual weighed bags.

Some Factors in the Selection of Machinery for Cargo Liners

No. II—(*Concluded from page 135, January 28th*)

By CDR. (E.) L. BAKER,* D.S.C., R.N. Ret.

Rather more than twenty years ago Cripps (1930)† *presented a paper on the broad economic factors of the operation of cargo liners and this was followed eighteen months later by some further consideration of the problem by Davis* (1932). *Much of what was then written is still true and the Thomas Lowe Gray lecture presented before the Institution of Mechanical Engineers on Friday, January 21st, was largely concerned with revising the data then presented. We here print extracts from the lecture.*

Progress of Diesel Machinery

THE progress of the diesel engine for marine propulsion has been quite astounding. In roughly thirty years the power installed in a given space has more than trebled as can be seen from Table II, which applies

TABLE II—*Progress of Diesel Propulsion in the Blue Funnel Fleet*

Date of construction	Number of screws	S.h.p. per shaft	Length of engine-room, ft
1922	2	2400	63
1926	2	3300	60
1929	2	4300	54
1938	2	6000	66
1945	1	6800	57
1949	1	7200	57
1955	1	8000	51

to ships of the same company and the same engine designer.

There has been steady development in the power taken together with a number of clearly defined changes of a more radical nature. In 1929 the four-cycle engine was supercharged ; in 1933 the two-cycle engine was introduced in the double-acting form and it is still the most compact and the lightest. In 1945 the " coverless " engine was built and, in 1949, the two-cycle single-acting engine was adopted to gain some simplification of maintenance at the expense of weight. The most recent designs which are due to enter service in 1955 are exhaust-turbine supercharged versions of the 1949 design.

One feature of the particular company's policy since the 1939–45 war has been the adoption of an increasing measure of standardisation even, in a few instances, at the expense of a slight loss in efficiency or of extra weight. For example, since 1949 the main engines for all motorships to be delivered and ordered have been of the same bore and stroke ; the diesel generators for motorships were of the same type from 1947 until 1954 when a new standard was adopted based on that fitted to the three 950 deg. Fah. steamships of the " Nestor " class.

The effect on the maintenance cost of supercharging a two-cycle engine has not yet been determined, but experience with the four-cycle supercharged engines gives hope that a considerable increase in rating may be obtained without deleterious effects. In any event, the blower power will be removed from the crankshaft with consequent effect on the net power for the same rating.

Finally, progress has been made in the weight and thermal efficiency of diesel ships as indicated in Table III.

TABLE III—*Weight and Thermal Efficiency of Machinery in Diesel Ships*

Year of completion	Machinery	Motorships maximum continuous shaft power, s.h.p.	Machinery weight, lb per b.h.p.	Fuel rate, lb per s.h.p. for all purposes	Efficiency, per cent
1929	T.S. diesel " SA4S " supercharged	8,000	450	0·40	34·3
1936	S.S. diesel " DA2S "	3,100	408	0·42*	32·7
1938	T.S. diesel " DA2S "	11,800	364	0·40	34·3
1943	S.S. diesel " DA2S "	8,000	351	0·39	35·2
1945	S.S. diesel " DA2S "	6,800	363		
1947	S.S. diesel " DA2S "	6,800	370		
1950	S.S. diesel " SA2S "	7,000	439	0·385	35·7
1955	Sketch design " SA2S " supercharged	8,000	327	0·38(?)	36·1(?)

* Increase due to disproportionate hotel load in this class of ship.

Cylinder-Liner Wear

The crux of the economics of burning boiler oil in diesel engines lies in the cylinder-

* Chief superintendant engineer, Blue Funnel Line.

† An alphabetical list of references is given in an Appendix.

liner wear. A simple four-stroke engine shows the same figures for liner wear, irrespective of the fuel burnt, but the double-acting two-stroke engine has a greatly increased wear rate on boiler oil despite the use of detergent cylinder oils.

An endeavour was made to establish the effective rate of wear from such curves as Fig. 6, but the variable factors appeared to be such that no satisfactory conclusion could be reached. The first step to eliminate the sources of error was to appoint one man to take all the wear measurements since it was

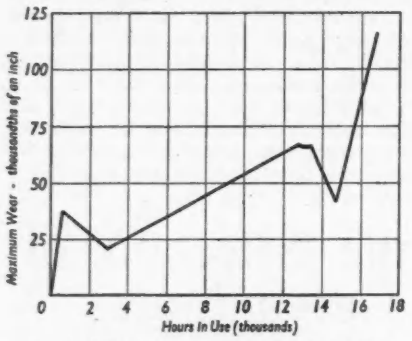


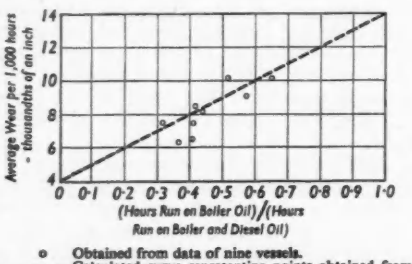
Fig. 6—Effective rate of wear of cylinder liner

found that the errors of measurement as between individuals outweighed the wear due to 1000 hours of operating life. Since that date, a limited number of liners had been worn to the limits and it had become apparent that the next difficulty was that although 160 thousandths of an inch total wear was allowed, the availability required of the machinery meant that few if any of the liners were removed at a wear of exactly 160 thousandths.

When sufficient data had been collected, statistical techniques were applied to a sample of eighty-three liners from nine ships with the following results :—

(1) Fifteen liners were removed from service owing to cracking ;

(2) Neglecting cracked liners, the method



o Obtained from data of nine vessels.
— — — — Calculated curve representing points obtained from given data.

Fig. 7—Wear of liners on boiler and diesel oil

of least squares gave the equation (Fig. 7)—

$$y=10x+4,$$

where y is average wear per thousand hours and x is the ratio of time on boiler oil to time on diesel oil. The above equation is substantiated by practical experience of liner wear on diesel oil and is in agreement with apparent results on boiler oil.

(3) By using the above equation to correct the actual hours of running to give 160 thousandths of an inch wear on boiler fuel only, the histogram shown in Fig. 8 was obtained ; from this it may be seen that no extraneous factor such as the type of piston ring or grade of cylinder lubricating oil exerts a major influence on the wear, within, of course, the limits of the types and grades used. This is somewhat surprising and it will be interesting to see whether this conclusion is substantiated by experience of a much larger sample in due course. With this wear rate approximately one-third of the profit in using boiler fuel is lost in extra replacement of liners and rings.

Progress of Steam Machinery

As the Blue Funnel Line had built no steamships for twenty-five years, the progress to be recorded is of shorter duration. There are three classes of ship involved, all of post-war construction, as shown in Table IV.

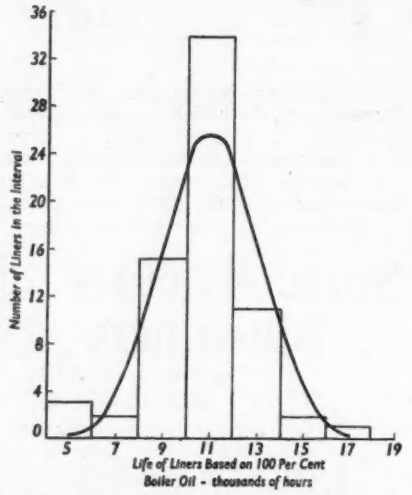


Fig. 8—Histogram for sixty-eight liners from "D.A. 2C" diesel engines

One of the most unsatisfactory features of two of the three classes of steamship is the wide range of fuel consumptions found in service. The Admiralty coefficients are not as widely spread as those of diesel ships, but whereas the specific fuel rate of diesel ships varies about 3 per cent, that of the two classes of steamship varies as much as 10 per cent from ship to ship. In the third case the variation appears to be very much less.

Standardisation

The post-war policy of this company has been to follow the general trends towards standardisation. When rebuilding a fleet of ships, half of which had been lost in the war, the advantages of standardisation became apparent and, when trying to maintain a high standard of efficiency in the post-war years, the disadvantages of not having adopted some considerable measure of standardisation in pre-war tonnage became equally apparent. It is, of course, essential to avoid stultification of progress, but if changes are made with intelligence a considerable measure of interchangeability can be achieved without preventing worthwhile development. A brief history of the "A" class serves to illustrate the point.

As originally conceived, the "A" class of motorship was propelled by an eight-cylinder double-acting two-cycle diesel engine of 6800 b.h.p. The generators were three five-cylinder engines of 220kW output each, and the lubricating oil pumps were two of 350 tons per hour output. After the first twelve, the main engine was changed to a seven-cylinder single-acting engine of larger bore and stroke, giving 7000 b.h.p., but the other units remained the same. After the first four of the modified "A" class, three 250 tons per hour lubricating oil pumps were substituted for the two pumps in order to enable a complete separation of the bearing and piston cooling systems to be achieved. After the ninth of the modified "A" class the main engine is again being changed so that 8000 b.h.p. can be achieved as a super-charged six-cylinder version of the seven-cylinder engine, the liners and pistons being interchangeable. The tailshaft and propeller of the latest design are interchangeable with the seven-cylinder ships and with the "Nestor" and "Neleus," the two steamers of 8000 s.h.p., but not with the original ships. At the same time as this change is being made the policy in regard to the generators has been changed so that two 450kW "V 8" generators replace the three 220kW generators. In all essential parts, except the blowers, these new engines are identical with the 350kW engines fitted in the steamships.

Repairs and Stores Costs

A complete analysis of the costs of maintenance of a fleet of ships might well be the subject of a thesis for a research student since it is practically impossible to decipher any significant trends owing to the heavy weighting caused by chance circumstances.

Tables V and VI give a breakdown of costs for a typical voyage of a modern steamship and a modern motorship. It will be noted that boiler repairs are the largest single item and that costs to meet the survey requirements are more than 10 per cent of cost. It will also be noted that the feed pump accounts for 5 per cent of the costs.

Table IV—*Progress of Machinery in Steamships*

Year of completion	Steam conditions	Maximum continuous power, b.h.p.	Length of engine-room, ft	Machinery weight, lb per s.h.p.	Fuel rate, lb per s.h.p. for all purposes	Thermal efficiency, per cent
1949	S.S. turbine, 450/750 deg. Fah....	6,800	58	250	0·61–0·65	22·5–21·1*
1949	S.S. turbine, 525/850 deg. Fah....	15,000	63	209	0·56–0·61	24·5–22·5*
1952	S.S. turbine, 625/950 deg. Fah....	8,000	51	243	0·53	25·9
—	Sketch design, S.S. turbine, 625/950 deg. Fah....	11,500	54	207	0·52(?)	26·4(?)

* Range of performance covers number of nominally identical ships and machinery.

Table V—*Sample Voyage Cost of Engine Repairs for Modern Steamship*

(Steam conditions 525 lb per square inch, 850 deg. Fah.)

	Per cent
Engine and ancillaries :	
Survey :	
Main gearing and pinions }	2·78
Main gear wheel bearings }	
High-pressure turbine	11·00
Clean port and starboard boilers, repair brickwork, overhaul mountings	13·25
Survey and overhaul :	
Turbo-generator	3·85
Low-pressure air vessel...	0·61
Sea-water evaporator	1·67
Manœuvring valves	1·67
Overhaul :	
Refrigerating compressor and condenser and brine pump	3·30
No. 2 auxiliary engine...	8·05
Auxiliary boiler, repair brickwork, examine mountings	3·58
Clean main condensers, renew and rubberise one length of injection pipe	7·15
Steering gear	1·67
Calorifier	0·74
Feed pump	5·13
Sea valves and grids	5·85
Miscellaneous :	
Principal items: "Pneumercators," gauges, renew pipes and clips, refrigerating thermostats, lag pipes, remove and replace floor plates in way of injection and modify, overhaul boiler damper wires and quick-closing valve control wires	8·20
Spare gear :	
Principal items, including three auxiliary engine heads, one piston, two liners, one pressure gauge tester, one "Airnesco" air lance	21·60
	100·00

In the case of the motorship the renewal of two liners accounts for about one-half of the cost, whilst the fuel injection pumps and valves of the main engine account for nearly 10 per cent.

TABLE VI—*Voyage Cost of Engine Repairs of "A" Class Motor Vessel*

	Per cent
Engines and ancillaries :	
Survey and overhaul :	
No. 5 unit and crosshead	2·83
No. 7 unit and crosshead and change liners	20·23
Overhaul :	
No. 2 unit and crosshead and change liners	20·23
Prepare stowage for spare liners, remove and replace skylights, &c.	1·89
Survey and overhaul :	
Forward crankshaft	4·23
Forward blower, and renew rubber bushes	1·29
Remetal No. 3 bottom end and No. 7 aft eccentric	5·52
Overhaul :	
High-pressure fuel pumps and fuel valve nozzles	9·32
Fuel pipes and pressure gauges	0·46
Tachometer, counter, pyrometers, indicators	0·46
Crankcase door sills	1·10
Survey and overhaul :	
No. 3 auxiliary engine	4·23
Auxiliary boiler and mountings, repair brickwork	1·10
Overhaul :	
Auxiliary feed pump, fit reconditioned pump	1·29
Main feed water cooling pump	0·09
Forward fire and bilge pump, float gear and valves	0·09
Auxiliary sea-water cooling pump	0·33
Sanitary pump, build up casing and recondition impeller	0·73
Survey and overhaul :	
Emergency fire and bilge pump	0·09
Port lubricating oil pump	0·55
Steering gear	1·10
Sea valves, grids, 25 per cent storm valves	3·88
Overhaul :	
Fuel oil separator	0·67
Refrigerator equipment	2·76
Miscellaneous :	
Principal items : engine-room vent flaps ; port and starboard oil fuel settling tanks, pressure tested ; fire extinguisher ; pneumercators ; pipes ; wind-lass guards ; lubricating oil drain tanks tested and tank top cleaned	3·40
Spare gear :	
Principal items: filter packs, piston rings, stuffing box distance rings, high-pressure fuel pump parts, fuel valve parts, auxiliary engine parts, separator parts, gland packing and compressor rings	12·13
	100·00*

* The actual total figure in £ sterling for Table VI was 199·19 per cent of that for Table V.

Evolution of a Design

From the broad statement of the problem and the accepted limitations, the naval architect proceeds on the basis of past designs to "cut and try." At the same time, the superintendent engineer is preparing alternative machinery arrangements based on a preliminary estimate of the power and using any or all of the possible combinations of types of propulsion.

After a number of attempts the naval architect succeeds in producing one or more designs embodying most of the requirements of the owner and it remains to evaluate them as carefully and as accurately as possible to decide whether any of them can meet the trade in view with a prospect of earning sufficient to make a profit.

An Example of the Analysis of a Design

When the naval architect and the superintendent engineer have completed their development of the designs, the owners have to select the most economic alternatives for final development into completed basis plans and specification ; in difficult cases it may be necessary to complete both steam and diesel engine designs and to obtain alternative tenders before the final choice can be made. This step will, of course, be necessary before it can be ascertained whether it is economically justifiable to build the ship. A hypothetical case is set out in Tables VII, VIII, IX and X and serves to illustrate how this procedure is worked out.

Effect of Fuel on the Choice of Machinery

It will have become apparent from the above that in the fringe zone the type and quality of the fuel burnt in the propulsion plant exerts a controlling influence on the type of machinery to be fitted. It may be pertinent, therefore, to review the possible future trends. The residual fuels generally available are suitable for use under boilers or in large slow-moving diesel engines.

At present marine diesel installations can burn the residual fuels commonly available in the bunkering ports, although in some instances there may be a limitation of viscosity applied solely to suit the capacity of the steam heating installation. The additional liner wear absorbs one-third of the saving in fuel cost ; any adverse change in the rate of liner wear would rapidly cause the use of residual fuels to become uneconomic, in which event steam turbines would be the first choice for most cargo liners.

A similar result would probably accrue from changes in the viscosity ranges of fuels available abroad, particularly when these were accompanied by differential prices between, for example, a fuel of 6500 seconds viscosity and one of 1500 seconds.

Of the future prospects of the vaguely defined "quality" of oil fuel it is difficult to write with certainty. Oil experts do not agree ; on the one hand Martin (1954) states "the conclusion can reasonably be drawn that marine fuel oils to-day are at least as good and often better in quality than those of a generation ago," whereas at the same date Habermann, Albright and Killingsworth (1953) say, "Years ago there were few problems connected with burning residual fuel . . . also it was far better in quality than it is to-day."

The author inclines to the latter view since, in the absence of contrary evidence, it appears to be certain that sulphur compounds are a major factor in that part of the wear of liners and rings which is due to corrosion, and that higher sulphur contents will probably result in increased corrosion.

Habermann and his colleagues summed up the future trends of residual oil fuel as under :—

(1) Specific gravity will increase and will approach or exceed unity (N.B.—Canadian fuels have reached 1·046).
(2) Viscosity will increase.
(3) Pour points will increase.
(4) Carbon residue will increase.
(5) Sulphur content will increase but wide variations will occur owing to the variations of sulphur content of the crude, and
(6) Ash content will increase.

All these factors in their various ways will probably increase the difficulty of operating diesel engines on boiler oil. Some factors, such as specific gravity in excess of unity, would necessitate a complete revision of separator techniques, whilst others, such as increased viscosity and ash content, might make efficient separation impossible. The probability is therefore that, in so far as the quality of fuel oil affects wear, the rate of liner renewals will increase with the decreasing quality of the fuel : from this, of course, can be deduced the fact that the point of balance between diesel and steam machinery may be shifted by the inability of the diesel engine to consume a fuel with as high a residual content as the steamship can use efficiently under boilers.

Basically, however, this is no new problem to the shipping industry which became so accustomed to the adjustment of prices between coal and oil as to keep the field open for exploitation of both fuels. The end was, of course, eventually attained when coal was priced out of reach after the 1939–45 war. Possibly a decision in this new case will eventually be reached in the same way, for the price ratio of diesel oil to boiler oil at Aden has now reached 1·62, and differential prices for various grades of boiler fuel may well spread to the more popular bunkering ports.

TABLE VII—*Statement of Requirements for a New Design by Owners*

Item	Requirements
Speed	16·5 knots minimum service speed
Cargo :	
Bale capacity	14,500 tons to 40 cu. ft. maximum
Deadweight	8500 tons on winter draught weather
Liquid cargo	Two tanks of 100 tons; two tanks of 250 tons ; one tank of 500 tons
Hazardous cargo	Lockers
Cargo handling	Usual standard and heavy derrick on Nos. 2 and 5 hatches
Crew	Chinese
Passengers	A limited number

TABLE VIII—*Summary of Design Provided by Naval Architect*

Item	Steam turbine ship	Diesel motor-ship	Required
Speed, knots	17	17	16·5 plus
Bale capacity, tons	14,540	14,190	14,500
Deadweight, tons	8,465	8,040	8,500
Liquid cargo	Tanks Tons	Tanks Tons	Tanks Tons
	2 × 110	2 × 110	2 × 100
	2 × 275	2 × 250	2 × 250
	1 × 600	1 × 600	1 × 500
Passengers	26	26	A limited number

TABLE IX—*Comparisons of Design with Requirements*

Item	Steam turbine ship	Diesel motor-ship	Existing ship
Hull weight, tons	5,855	5,905	4,518
Machinery, tons	960	1,510	1,262
Deadweight, tons	10,285	9,685	9,295
Summer displacement, tons	17,100	17,100	15,075

Item	Steam turbine ship	Diesel motor-ship	Existing ship	
			Design	Actual
Speed, knots	17	17	15·5 plus	16·17
Power, s.h.p.	10,500	11,000*	6,720	6,720
Fuel consumption, tons per day	58	47	27·9	27·8

* An allowance of 5 per cent extra power to ensure margin for effect of weather from data on previous ships.

TABLE X—*Economic Balance for a 25,500-Mile Voyage*

Item	Steam turbine ship, £	Diesel motor-ship, £
Fuel, 687 tons, costing 124s. per ton	4259	—
Lubricating oil (differential)	—	855
Maintenance (differential)	—	2800
Canal dues (differential)	225	—
Totals	4484	3655
	3655	
Net extra cost of turbine per voyage	829	
Extra earning capacity	350 tons bale, 425 tons deadweight	

Deformed Bar for Prestressed Concrete

A DEFORMED steel bar for prestressed concrete has been introduced by McCalls Macalloy, Ltd., Templeborough, Sheffield. These bars have been developed to give economies over the round bar post-tensioned method for the shorter lengths under about 25ft. For concrete members under that length there are cases where economy could be obtained if the bond could be developed enough to reduce the cost of the end anchorages for the smaller diameter bars. This particularly applies, we are informed, to precast floor units where the lengths are usually below 20ft and the cost of the end anchorages by any system of post-tensioning is a high proportion of the total cost of the steel.

The Macalloy deformed bar has deformations complying with ASTM A305—50T and in a typical method of use has one end threaded for attaching the jack and tensioning. The other end has a wedge-in-collar grip or a threaded end. All the end fittings are recovered. These high-tensile alloy steel deformed bars can be used for pre-tensioning or for post-tensioning, and the prestress is distributed at the ends of the member by wire helices in the concrete around the ends of each bar.

The bars are manufactured to B.S. 970 : 1947, with two longitudinal ribs joined by a transverse rib at about 60 deg. to the axis. The minimum 0·2 per cent proof stress is 58 tons per square inch and the ultimate tensile stress about 70 tons per square inch. The bars may be stressed individually or in groups, using crossheads and holdfasts.

Constant-Frequency A.C. System for Aircraft

A method of generating constant-frequency a.c. supplies from alternators coupled to aircraft propulsion engines, through the medium of the Sundstrand constant-speed drive, is described here. The Sundstrand drive is a variable-ratio hydraulic transmission, used differentially so that it handles only the power represented by the difference in input and output speeds. In the 40kVA equipment described the alternator speed is kept constant at 6000 r.p.m. ± 1 per cent, despite variations in engine speeds between 8300 r.p.m. and 3000 r.p.m. The system is specifically designed for parallel operation of a number of engine-alternator sets, and it provides for sharing of the resistive and reactive loads.

A CONSTANT-frequency a.c. equipment for aircraft electrical systems was demonstrated recently at the Acton works of D. Napier and Son, Ltd. It is designed to enable a number of alternators to be run in parallel with the frequency controlled to ±1 per cent under all conditions of load and engine speed and so to remove the main impediment to the use of alternating current in aircraft. The equipment, which is known as the Sundstrand constant-speed drive, is not new ; it was developed during the recent war, in the 1940s, by the Sundstrand Machine Tool Corporation of America and it is now being manufactured under licence in this country by the English Electric Company, Ltd.

Briefly the arrangement is that each of the aircraft propulsion engines is coupled to an alternator through the medium of a Sundstrand constant - speed drive, which is a positive-displacement hydraulic transmission consisting of a variable - stroke pump and a fixed-stroke motor. The pump and the motor, as described more fully below, are combined in a rotating cylinder assembly in such a way that only the power represented by the difference between the input and output speeds is handled by the pump and motor. In its present form the drive is designed to transmit 50 h.p. continuously with an input speed range of 3000 r.p.m. to 8300 r.p.m., the alternator speed being 6000 r.p.m. and the output being generated at 200V, three phase, 400 cycles per second, ±1 per cent.

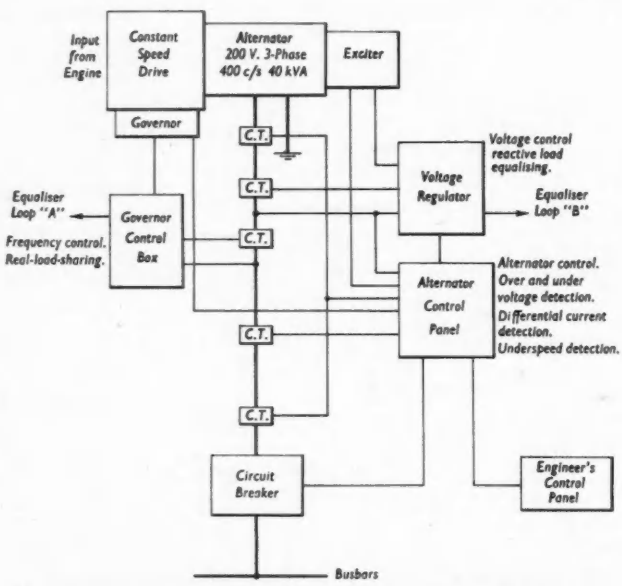


Fig. 1—Block diagram of control system for alternator with Sundstrand drive

As shown by the block diagram in Fig. 1, the system consists of the following main components : a constant-speed drive and a governor control unit to effect frequency control and to ensure sharing of the real load between the alternators connected in parallel ; an alternator, a voltage regulator and reactive load sharing control ; an alternator control panel to provide facilities such as fault protection ; a main circuit breaker ; a synchronising unit ; and current transformers for the protective circuits and for real and reactive load sharing. In Figs. 2 and 3 we show a 40kVA unit. Within the cylinder block assembly (Fig. 2) can be seen the pump *A* at one end and the motor *B* at the other. The units are bolted together with the port plate *C* positioned in between to direct the fluid between the pump and the motor. The transmission is driven by the main engine through gears *D* which rotate the cylinder assembly.

Initial rotation of the input shaft simultaneously starts the make-up and scavenging oil pumps *E* and *F*. As the pump and motor are not self-priming, a gear type make-up oil pump is used to deliver oil to the pump and motor assembly and the governor system. This make-up oil pump supplies the inlet of the main piston pump and motor so that the pistons *G* and push rods *H* will be held in contact with the output controlling swash plate assembly at all times and ensures that a full charge of oil will be maintained in the high pressure hydraulic circuit.

As the make-up pressure holds the pistons against the swash plate assembly *J* piston stroking is accomplished when the cylinder block is rotated. The displacement of the pump is regulated by the angle of the swash plate which is determined by the governor system through a hydraulic signal. The manifold assembly *K* serves to deliver make-up oil to the pump and return oil to the pressurised case.

The motor cylinder block assembly *B* receives high pressure oil which forces the pistons to move out against the fixed-angle swash plate *L*, thus converting axial-piston movement into rotary motion. The swash plate is free to rotate independently of the rotating cylinder block and hence can operate at speeds in excess of or below that of the rotating cylinder block assembly. The offset of the motor valve plate *M* is always in the same position with respect to the angular position of the swash plate, this being such that the motor push rods are exerting a clockwise torque upon the swash plate.

With the pump swash plate in maximum overdrive (maximum positive angle), the output shaft is overspeeding the input shaft. After gear ratio corrections, this overspeed is the ratio of maximum pump displacement to the fixed displacement of the motor minus piston leakage. The swash plate remains in this maximum stroke position until output speed reaches 6000 r.p.m.

With further increase in input speed, the normal tendency is to increase the output speed. At this point, however, the governor regulates the control piston *N* and swash plate assembly to decrease pump piston stroke. Less oil then flows from the pump to the motor and therefore the differential speed between the motor shaft and the cylinder block assembly is reduced to retain constant output speed.

When the input speed exceeds the governed output speed the cylinder block assembly will be turning faster than the motor shaft which always operates at constant speed. Relative motion between the cylinder block and motor shaft will now be in a reverse direction since it is now necessary to subtract from input speed to maintain governed output speed. Due to the cylinder block overspeeding the motor shaft, the pump swash plate is held in an underdrive position (negative angle) which permits an oil flow from motor to pump. In effect, the pump is now motoring and the power flow in the hydraulic units is reversed.

Leakage from the cylinder block assembly and lubricating oil which drains back into the unpressurised case is picked up by a gear type scavenge oil pump *F* and returned to the external reservoir. The scavenge pump, which is attached to the same shaft as the charge oil pump *E*, is large enough to ensure a dry case condition at all times.

The alternator is driven through a full complement over-running, sprag type, one-way clutch located in the output gear and clutch assembly *P* of the transmission. This clutch is necessary to prevent power from being directed through the transmission opposite to that from the main aircraft engine under conditions when the alternator is tending to act as a motor.

As the output speed has to be regulated to 6000 r.p.m. constant, the speed signal for the governor system is taken from the output gear and clutch assembly. This signal is transmitted through the tachometer drive shaft and centrifugal switch to the governor assembly.

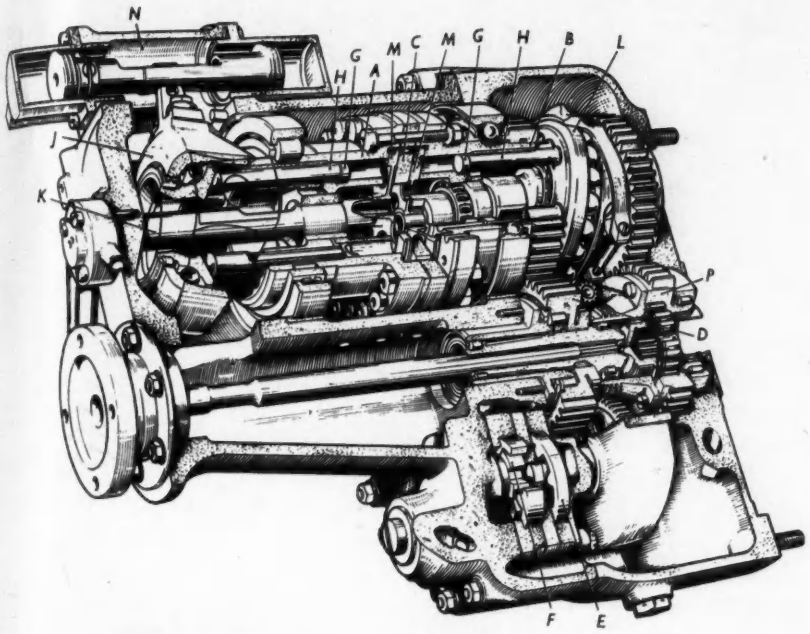
Hydraulic Circuit.—Initial rotation of the input shaft simultaneously starts the cylinder block assembly rotating as well as the charge and scavenge oil pumps. The charge pump picks up oil from the external reservoir and delivers it through the oil filter and manifold assembly to the charge oil section between the pump and motor cylinder blocks. Oil returns from the cylinder block assembly through the manifold return line to the charge pressure relief valve. This valve maintains the charge pressure at 300 lb per square inch, the excess dumping over the valve into the pressurised case. A by-pass taps off oil from the manifold return line and supplies the oil to the governor system and wobbler control pistons. The purpose of the pressurised case is to supply pressure lubrication to the various rotating parts of the transmission through properly located jet nozzles. Oil drains from the pressurised case to the unpressurised case through the lubricating oil relief valve which is adjusted to open at a pressure of 20 lb per square inch. Leakage from the cylinder block assembly and lubricating oil, which drains back into the unpressurised case, is picked up by the scavenge pump and returned to the reservoir. The oil cooler must be of adequate capacity to deal with the heat losses of the drive as indicated in the following table :—

Drive input speed, r.p.m.	Heat rejection in B.Th.U.'s per hour	
	100 per cent load	50 per cent load
3,000	19,000	10,000
4,000	19,000	10,000
5,000	20,000	10,500
6,000	22,000	12,000
7,000	26,000	15,000
8,000	30,000	20,000

The use of a fuel-cooled oil system often enables a very useful weight reduction to be effected.

Basic Governor System

The governor system has two functions : to keep constant the output speed (and therefore alternator frequency) and to equalise real load among paralleled alternators. Each drive-alternator control system consists of a governor control, a precision frequency control motor and a frequency and load controller. The arrangement and operation of these elements make it possible to control accurately the pump swash plate angle through the control pistons,



A—Pump cylinder block.
B—Motor and pump cylinder block.
C—Port plate.
D—Input gear.
E—Charge pump.
F—Scavenge pump.
G—Pistons.
H—Push rods.
J—Pump swash plate assembly.
K—Manifold assembly.
L—Motor (fixed angle), swash plate.
M—Motor and pump valve plates.
N—Swash plate control assembly.
P—Output gear and freewheel clutch assembly.

Fig. 2—Positive displacement hydraulic transmission giving constant speed output. Basic components include two axial piston swash plate units, both arranged to pump or motor

and hence to control output speed of the transmission.

If, owing to a change in engine speed or alternator loading, the frequency tends to drift from the correct value, a frequency discriminator circuit develops a rectified d.c. signal proportional to the deviation and of appropriate polarity, depending on whether the frequency is tending to increase or decrease. The signal is taken to a magnetic amplifier which produces an equivalent a.c. signal which is fed to one winding of the two-phase governor control motor, the other phase being supplied with a fixed phase voltage. The control signal leads or lags this voltage by 90 deg. and so causes the motor to rotate and adjust the governor control spring setting to correct the frequency deviation.

The governor control is a spring-biased, fly-ball-operated, hydraulic control valve. Its function is to control the porting of oil under make-up pressure to the overdrive and the underdrive control cylinders. A rotating sleeve in the governor control is driven from an output gear of the drive, and is, therefore, responsive to output speed. At one end of the sleeve are two flyweights whose arms tend to move a two-land valve stem in the sleeve against the tension of two springs : the main spring, whose tension is preset, and a smaller bias spring whose tension is controlled through a plunger rod by the precision frequency control motor.

Four ports connect to the valve chamber in the sleeve : an inlet port carrying make-up pressure oil, a port which drains to the lubrication circuit, a port to the overdrive control cylinder, and a port to the underdrive control cylinder. The groove between valve stem lands is opposite the port carrying make-up pressure oil. When the output speed of the drive varies from the set value, as during starting or changes in load, the valve stem moves up or down, porting make-up pressure oil to either the underdrive control cylinder or the overdrive control cylinder, and porting the other to drain into the lubrication circuit. When the output speed is correct the valve stem will be positioned so that its lands cover the ports to both control cylinders and the pump swash plate will be held in position.

Load Sharing.—Sharing of resistive (real) load between parallel alternators and drives is accomplished by automatically adjusting the spring bias of the governor control associated with each drive. The spring bias is adjusted by means of a small geared, two-phase induction motor which receives signals from a magnetic amplifier controlled by current transformers in each of the alternator circuits.

The following table shows the load division obtained with this arrangement applied to the 40kVA unit. Under steady state conditions load sharing within 2kW is achieved.

Parallel Operation

Input speed	Input speed acceleration or deceleration, r.p.m./second	Drive load, kW	Average drive output speed, r.p.m.	Total load division between drives
3000–8000	0–50	30	6000±15	within 4kW
3000–8000	50–600	30	6000±75	within 12kW
5000–8000	600–1200	30	6000±60	within 14kW

Rating.—The 40kVA drive is rated as follows : full load continuous, 50 h.p. ; 5 minute intermittent, 75 h.p. ; 5 second intermittent, 100 h.p.

Alternator and its Associated Equipment

The alternator is a separately excited generator, the exciter being an integral part of the machine. The exciter is supported between the main bearings of the alternator and the characteristics of the combination are such that a high short-circuit current is available for fault clearing, and that the exciter cannot be demagnetised under short-circuit conditions. The harmonic content of the output is limited to provide a satisfactory waveform for aircraft applications. Iron losses are limited by the use of high-grade, low loss, core plate steel.

To enable the machine to operate at high temperature glass insulation is used and the windings impregnated with silicone varnish.

The Voltage Regulator.—Because of the limitations of the carbon pile regulator use is made of the magnetic-amplifier voltage regulator. The exciter field is connected to the output of the amplifier, the control winding of which receives a d.c. signal proportional to the alternator output. If the voltage generated by one of a number of alternators tends to fall, the other machines will take up more of the reactive load of the system. A current transformer and a " mutual reactor " (a transformer requiring a large magnetising current owing to an air gap in the magnetic circuit) are used to cause the voltage regulator of the low voltage machine to increase the excitation and so correct the deviation. The operation of the associated circuit will be explained below.

The Alternator Control Panel.—The control panel is designed to ensure that an alternator cannot be connected to the line if its frequency, voltage or phase rotation are incorrect, or if there is a fault on the machine, and to remove the machine if any of these conditions occur whilst the machine is running. The control panel incorporates devices which detect the following faults : (1) line-to-line or line-to-neutral fault up to the alternator circuit breaker ; (2) under or overvoltage ; (3) phase sequence, a function covered by the undervoltage unit to guard against incorrect installation ; (4) underspeed. Overspeed protection is arranged mechanically at the constant-speed drive.

Main Circuit Breaker.—Each alternator is connected to its busbar by an English Electric " 681 " circuit breaker. It is electrically closed and tripped and uses double-break sintered contacts. It is rated at 120A, with an interrupting capacity up to 4000A at an altitude of 60,000ft. The " closing " coil is automatically disconnected from its supply when the closing operation is complete and the main contacts are held closed by a mechanical latch which can be released by the " opening " solenoid. Auxiliary contacts are provided for interlocking and indicating purposes.

Real Load Sharing

As can be seen from Fig. 4, the single phase input transformer to the circuit has two secondary windings T_1, T_2, so connected that when no voltage is produced by the current transformer across resistor R_1 there is no d.c. voltage across potential divider P_1. Under balanced loading conditions the " in phase " or power component of the voltages appearing across the R_1 resistors are equal ; each of these components arithmetically adds to and subtracts from the respective T_1 and T_2 outputs, thus causing the same potential difference across the potential dividers. Therefore no current flows in the magnetic amplifier control windings and equaliser loop *A*. If, however, No. 1 machine tends to reduce its speed it begins to shed real load which must be taken up by the other machines. The voltage across the R_1 resistor falls by an amount proportional to the reduction in load. The voltage across the other R_1 resistors increases by one-third this value (with four machines on line). Hence current flows from P_1 on the three machines, out of the respective magnetic amplifier control windings and equaliser loop *A* and into the control winding of No. 1, so biasing the drive governor to tend to increase the speed. At the same time the other machines lose speed momentarily, thus restoring balance. The system frequency does not actually change during this process, being held constant by the frequency

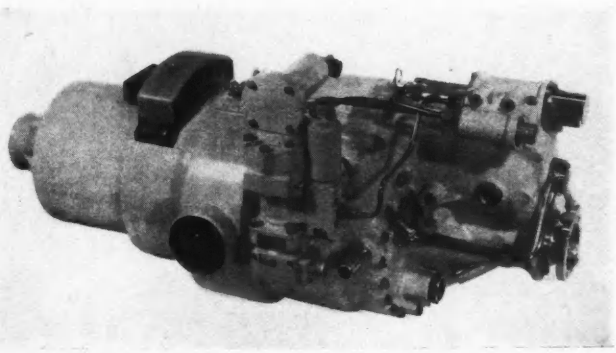


Fig. 3—40kVA packaged Sundstrand constant-speed drive with alternator

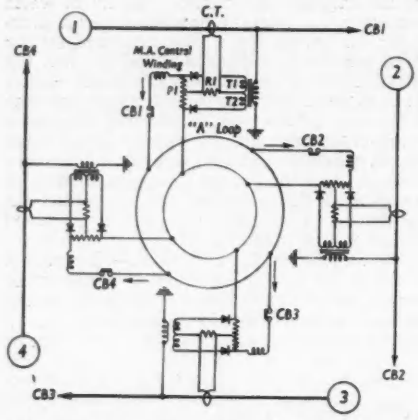


Fig. 4—Principle of operation of real-load-sharing circuits

discriminator circuits. The interlocks in the connection to loop *A* disconnect a machine from the load sharing circuit when the circuit breaker opens. Since only the "in phase" component of the voltage appearing at R_1 is effective, unbalance of reactive currents is not detected in this circuit.

Reactive Load Sharing

With reference to Fig. 5, under balanced reactive load conditions the output of each open delta or "V" transformer is taken directly to the rectifier supplying the voltage regulator control coil. The current in the current transformer secondaries circulates round the equaliser *B* loop alone.

If the voltage of one machine begins to increase, the machine takes up more than its share of the reactive load, the other machines each losing one-third of this amount. The secondary current of the "overvolting" machine C.T. increases correspondingly but as the current in loop *B* can only have one value, a current circulates in the mutual reactor secondary causing a voltage to be injected into the supply to the rectifier such as to increase the average input and thus the d.c. output voltage. The regulator senses overvoltage and operates to reduce alternator excitation. At the same time the voltage of the other machines tends to rise since the respective mutual reactor signals reduce the signals to the regulator coils. The

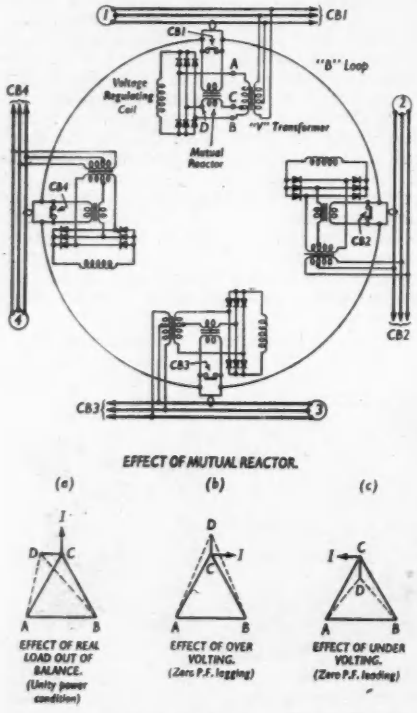


Fig. 5—Principle of operation of reactive-load-sharing circuits

90 deg. phase shift of mutual reactor secondary voltage relative to its primary current ensure that changes in resistive or real load have little effect on the signal to the voltage regulator coil. On the vector diagrams the voltages *A*,*B*,*D*. are those taken to the rectifier and the d.c. voltage depends upon their average.

Fault Detection

Over- and Undervoltage Units.—These devices protect the system from the overheating effects due to the large circulating reactive currents resulting from a machine developing under or over excitation. The units are made selective (only removing the faulty machine from the system) by employing the current transformer-mutual reactor circuit. Then if the voltage of one machine falls to 180V on a four-machine system, the busbar voltage falls to $(3\times200+180)/4=195$V. The mutual reactor must inject a signal which will produce an average line voltage applied to the under and overvoltage units of 180V. It can be shown that the bias voltage required is 27V. At the same time the sound machines are biased by a signal of $27/3=9$V in the opposite sense, and the average voltage seen by their detecting units can be shown to be 200V even though the system voltage is at 195V. A similar argument can be applied to the case of the "overvolting" machine: with this generating 220V, the busbar voltage becomes 205V, the faulty machine detector senses 220V and the other 200V. The under and overvoltage units are set to trip when the machine voltage exceeds the range 180V to 220V but time delays are introduced to ensure that load surges do not cause nuisance tripping.

Line-Line and Line-Earth Faults.—Merz-Price differential current protection is used against line-line and line-earth faults. The neutral lead of each of the alternator phases is brought out and passed through a ring type current transformer. Another transformer is placed over the outgoing phase lead, the two secondaries being connected together and to the coil of a small a.c. relay. Under normal conditions the two primary currents are equal in magnitude but opposite in phase and no current flows in the relay coil. If a fault occurs on the line between the two transformers the two primary currents will become unbalanced. When the out of balance reaches 40 per cent of normal full load value the relay closes and removes the faulty machine from the busbar.

In a typical feeder arrangement for a four alternator system the main busbars are split into four sections with four synchronising circuit breakers. Normally the system operates with all the circuit breakers closed but in the event of a major fault on any section the appropriate synchronising breaker can be opened, thus leaving three-quarters of the main busbars alive. To take full advantage of this layout the essential services can be distributed between the four sections.

Test Rig

To enable Sundstrand constant drive units to be subjected to the kind of duties that they would meet in multi-engined aircraft a test rig installation has been established in the Acton works of D. Napier and Son, Ltd. In this plant there is provision for testing two Sundstrand units in parallel and the test cell housing these units can be viewed through a window in the adjoining control cabin as shown in Fig. 5. Each Sundstrand unit is driven by a Rover "Meteor" engine through a 3½ to 1 ratio gearbox and a torque meter.

On the control desk (Fig. 6) there are indicating meters to show the input speed, frequency, real

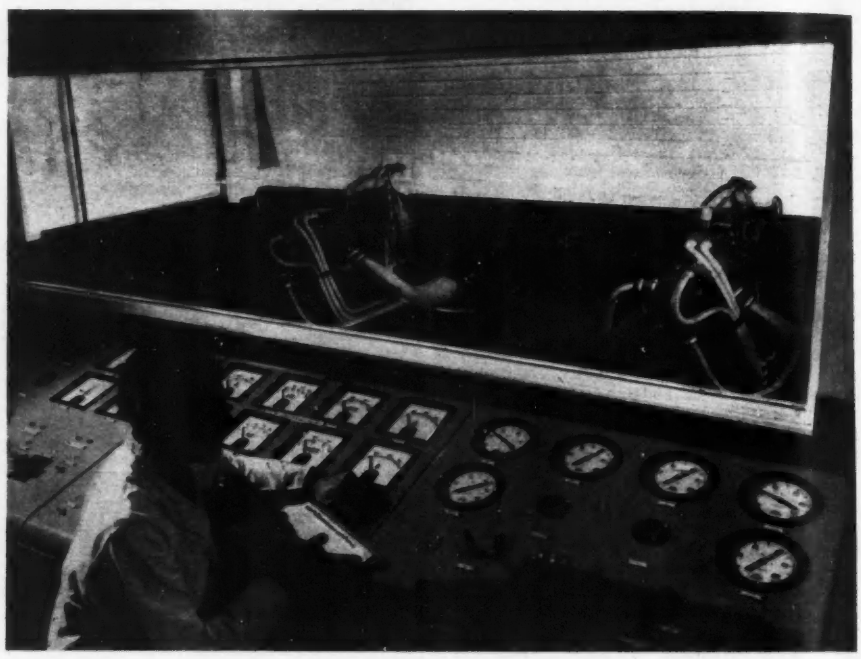


Fig. 6—Control panel and two Sundstrand constant-speed drives with slave alternators forming part of a test rig arranged to demonstrate the performance of the system singly or in parallel

power, reactive power, voltage and frequency of each Sundstrand drive. A separate panel houses the engine controls.

Besides the meters there is a system of switches which, operating through relays, enables various resistive and reactive loads to be applied; one of these switches imposes a pulse load of 8kW for 40 milliseconds in every half-second, to simulate a radar installation. The circuit breakers for each set are mounted on one of the panels, together with a synchronising lamp circuit which is used for manual synchronising of the machines. In this particular development rig the alternator and its exciter are separate but the airborne version will have the two machines combined. There is a system of blast air cooling supplied to the machines from external fans.

The Sundstrand units are complete with their voltage regulators and frequency control units, but the oil system is taken into the engine cell and consists of a supply tank, filter and heat exchanger; the oil used is a synthetic oil conforming to D.Eng.2487.

In the demonstration which we attended the performance of the equipment was shown first with a single Sundstrand unit and then with two units in parallel. Details of the tests that were applied, to show the ability of the units to

maintain constant speed under steady and transient conditions, are tabulated herewith.

TABLE—*Demonstration of Sundstrand Constant Speed Aircraft Alternator Drive*

Single Alternator Operation

Operation	Nominal load kW	Nominal load kVAr	Input speed, r.p.m.	Approximate acceleration and deceleration, r.p.m. per second
Start up engine ...	—	—	5000	—
No load acceleration and deceleration	—	—	3000 to 8000	500
ditto	—	—	3000 to 8000	1000
Load switching up to 40kVA	8	—	5000	—
	16	+Pulse	5000	—
	16	+ 24	5000	—
	24	+ 24	5000	—
	32	+ 24	5000	—
Full load acceleration and deceleration	32	—	4000 to 8000	500
Half-load acceleration and deceleration	16	—	4000 to 8000	500

Parallel Operation

Operation	Total nominal load kW	Total nominal load kVAr	Input speeds r.p.m. No. 1	Input speeds r.p.m. No. 2	Approximate acceleration and deceleration, r.p.m. per second
Parallel alternators with load on one only	16	—	5000	5000	—
Load switching up to 80kVA	16	—	5000	5000	—
	16	+Pulse	5000	5000	—
	32	—	5000	5000	—
	32	+ 24	5000	5000	—
	48	+ 24	5000	5000	—
	48	+ 48	5000	5000	—
	64	+ 48	5000	5000	—
Full load acceleration and deceleration	64	—	5000 to 8000	5000	1000
Half load accelera- and deceleration	32	—	5000 to 8000	5000	1000
"One - up, one - down"	32	—	8000	4000	—

One set was started and accelerated and decelerated at no load. Electrical loads were then added in various increments and the drive run at different speeds. With one set running under load, the second set was started and then run in parallel, and the various duties repeated. Then the two sets were run with one increasing and the other decreasing speed, and at the same time the electrical loads were changed. Finally, on shutting down, one machine was used to demonstrate the under-speed protection device, which becomes operative when the input speed falls below the minimum governing speed, as in the case of an engine failure. In this case the switch breaks a relay, in series with the circuit breaker, and takes that alternator off the busbar.

Hand Surfacing Tool with Renewable Blade

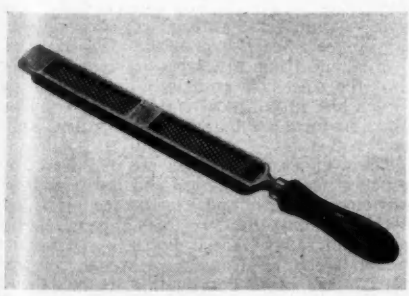
A NEW form of hand surfacing tool or file suitable for use on all materials up to the hardness of mild steel is being made by Firth Brown Tools, Ltd., of Sheffield, and distributed by Simmonds Aerocessories, Ltd., Treforest, Pontypridd, Glam. The tool consists of a light alloy holder with a wooden handle and fitted with a high-quality carbon steel cutting strip. One of the "Sureform" tools, as they are called, is illustrated below.

The cutting strip is corrugated diagonally and on the top of each corrugation there are formed a number of 0·008in deep cutting edges, each with a 35 deg. cutting angle. The side of the corrugation immediately below each cutting edge has a small hole punched in it. It will be appreciated that, irrespective of the softness of the material being filed with the tool, the maximum depth of cut per tooth is 0·008in and as the material is removed it is forced out through the hole below the tooth. Thus the teeth cannot become clogged with a soft material as it is removed, and as the depth of cut is strictly controlled the edges of thin materials such as plywood are not spalled when surfacing or cross cutting. Each tool has some 500 cutting teeth formed on its working face.

The tool can be used effectively on mild steel, copper, aluminium, &c., as well as on a variety of other material, such as wood, rubber, leather, fibre, plastics, &c. Makers' tests, some of which were carried out in our presence, have shown that the new tool is capable of removing these metals and materials very much more quickly and effectively than normal rasps or rough files.

When the teeth on the cutting strip or blade of a tool become worn the blade can be removed by the loosening of a tensioning screw at the front of the holder, and replaced by a new blade.

Another application of the blades of these "Sureform" tools is in a form of plane. In this case the blade is rigidly supported along the foot of a plane of conventional shape and the tool can be used in the usual way for smoothing and trimming wood and other materials.



Hand surfacing tool for metals and soft materials fitted with a renewable cutting strip

Electric Arc Furnace in a Roll Making Foundry

WE recently visited the roll making foundry of R. B. Tennent, Ltd., at Coatbridge, near Glasgow, to see a new 12-ton electric arc furnace which was installed in the company's melting shop last year and is now in full operation.

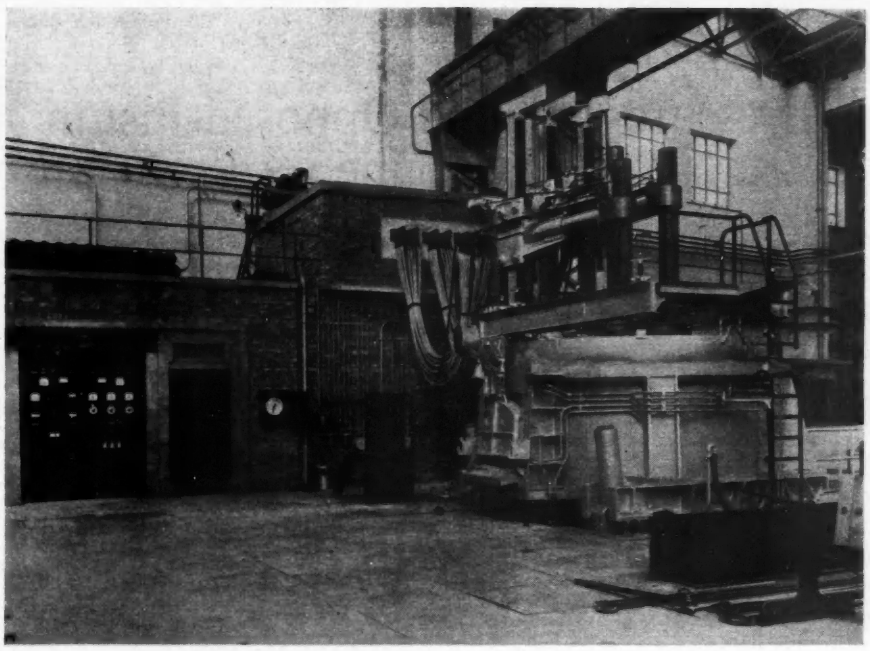
We may recall that the company was started as a small ironfoundry in 1857 by Robert Tennent, the grandfather of the present managing director. In those days the main products were hammer faces, anvils and castings for local ironworks machinery and for mines and blast-furnaces. By 1870 the need for expansion resulted in the works being moved to Whifflet, the present site. There a new foundry and machine shop were built, and equipped with two furnaces and cupolas, with which heavier castings could be produced. The company was becoming increasingly interested in the manufacture of rolls for the local ironworks, and by 1890 roll making formed an important part of the output.

After a visit to Germany in 1879 Mr. R. B. Tennent obtained the rights of the Gontermann-Peipers method of chilled roll moulding and began to develop techniques for making large chilled rolls for the manufacture of steel plates. In 1889 an additional foundry was built for making chilled rolls.

In 1900 the firm became a limited company and the building of a larger foundry (which is still the main foundry to-day) was begun. It was equipped with furnaces having a combined capacity of 100 tons. The first steel castings were made in 1905; initially the output consisted mainly of general castings, but the production of rolls gradually increased until now it forms more than 95 per cent of the firm's production. In 1908 the machine tools were moved to a new shop which now forms the roll turning department. Another new building, completed a year later, now houses the heat-treatment and dressing shop.

For the next twenty-five years these works met the firm's requirements, but in 1934 a new programme of modernisation and expansion was begun and, after being interrupted by the war, was resumed in 1948.

The first stage of this programme involved extensions of the present heat-treatment and machining facilities and, by 1950, two additional buildings had been completed. Oil-fired heat-treatment furnaces, heavy-duty lathes and ancillary equipment were then installed, the majority of the tools being of Craven manufacture and incorporating up-to-date British designs in roll machining equipment. The second stage of the programme was started in 1950 and completed this year; it consists of an additional foundry connected with the existing foundry



12-ton electric arc furnace installed in a roll making foundry. The heavy current cable and connections to the transformer house can be seen. The main control panel, on the extreme left, is built into the substation wall

by an electric transfer car and equipped with sand handling, moulding, drying, melting, casting and annealing equipment.

The new melting furnace is a "Lectromelt" 12-ton electric arc furnace (as illustrated), built by Birlec Ltd., Tyburn Road, Erdington, Birmingham, 24. It has a diameter of 12ft and is made of heavy gauge steel plates lined with refractory material. A top stiffening bezel ring, which is water cooled, is provided to prevent distortion under heat. For slagging, oxygen lancing, fettling sampling and other operations there is a refractory-lined door let into the side, as can be seen from our illustration. On the opposite side of the shell is the pouring spout, which is also lined with refractory material. The roof refractories are supported on a water-cooled channel section ring which is suspended at four points on two structural steel beams, an arrangement which facilitates removal and replacement and obviates any trouble in aligning the electrode ports and electrodes. An eye attachment in the roof structure is engaged by a vertical hydraulic ram to lift the roof clear of the furnace for top charging purposes. When the roof is raised clear of the furnace body it is swung round through an angle of nearly 75 deg. to expose the hearth. Recharging can then be effected by lowering a drop-bottom bucket into the shell. These operations are interlocked in the correct sequence. Tilting is effected by a pair of hydraulic rams, the oil pressure being generated in a self-contained electrically-driven plant, installed in a basement. The three 10in diameter electrodes are fitted in water-cooled copper clamps and project vertically through the furnace roof. The clamps, which are operated by remotely controlled pneumatic mechanism, are mounted on the ends of horizontal arms which also carry the electrical and water connections. The horizontal arms are connected to vertical masts by crossheads which in turn are suspended from flexible steel cables connected to individual winches. These winches are installed in the basement below the furnace floor and are provided with drums over which the cables pass to terminate in counterweights. Each winch is driven through gearing from a direct-current motor, the field of which is permanently excited at constant voltage and the speed and direction of which depend on the magnitude and polarity of the output voltage of an amplidyne constructed by the British Thomson-Houston Company, Ltd., Rugby.

Electrical power for operating the furnace is obtained from the public supply mains at 11kV, three-phase through a metalclad switch supplied by A. Reyrolle and Co., Ltd., Hebburn-on-Tyne. This switch controls the supply to a 4000kVA transformer made by the Electric Construction Company, Ltd., Wolverhampton. The switchgear and transformer are housed in brick-built cells which can be seen, in the accompanying illustration, beyond and to the left of the furnace.

On the extreme left of the illustration is the control and instrument panel for the furnace. The main metering facilities are installed on the left-hand panel, which has indicating instruments for supply voltage, furnace current, furnace power and energy in kilowatt-hours. On the right there are three groups of hand-wheels and push-button controls with an ammeter for indicating the arc current in each phase. Remote indication of temperature, as registered by a thermo-couple probe, is given on a separate dial which can be seen just to the right of the door leading to the substation.

Pressure-Charged Opposed-Piston Engine

Since Harland and Wolff, Ltd., introduced its large single-acting, two stroke, opposed piston engine five years ago the company has been investigating the problems of supercharging. As a result of experimental work an engine has now been built incorporating exhaust gas turbo-blowers in the design in place of the positive displacement rotary blowers. The engine now undergoing trials has six cylinders of 750mm diameter by 2000mm combined stroke and develops 8000 b.h.p. at 112 r.p.m.

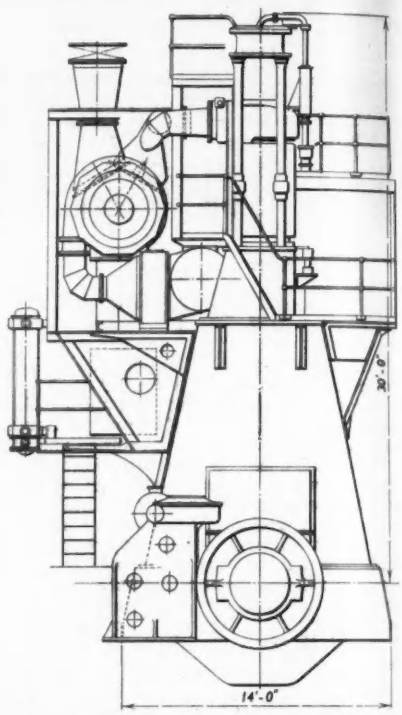
IT is almost five years ago since the shop trials were run of the first of a new series of engines designed and developed by Harland and Wolff, Ltd., Belfast. The engine in question was a single acting, two stroke, eccentric opposed piston, crosshead marine engine having seven cylinders of 750mm bore, the stroke of the main piston being 1500mm and that of the exhaust piston 500mm, to give a combined stroke of 2000mm. At 110 r.p.m. the engine was conservatively rated to develop 7500 b.h.p. with a mean indicated pressure of 6·1 kg per square centimetre. Since the introduction of this engine, which was described in THE ENGINEER of May 26, 1950, many of similar design have been built and have operated successfully as main propulsion units in large tankers and a wide range of cargo ships. In addition to the engine having a bore and combined stroke of 750mm by 2000mm the company has built another model having a cylinder of 620mm bore and a combined stroke of 1870mm, the power ranging from 3000 b.h.p. to 9000 b.h.p., continuous rating, for engines having four to eight cylinders.

Scavenge air for the engines was supplied by two positive displacement rotary blowers, of the builder's design and manufacture, mounted on brackets connected to the main frames at the back of the engine and driven through gearing by roller chains from sprocket wheels on the engine crankshaft. During the succeeding years Harland and Wolff, Ltd., has carried out a considerable amount of experimental work on the pressure charging of both four stroke and two stroke engines. This work has resulted in the application of pressure charging to large opposed piston engines and the first unit to embody pressure charging was undergoing extended shop trials last month at Belfast. The engine has six cylinders of 750mm bore by 2000mm combined stroke and has been built to the order of Alfred Holt and Co., for installation in that company's cargo liner "Demodocus." This ship, which has a length overall of 487ft, a breadth moulded of 62ft, a depth moulded of 35ft 3in, and a deadweight of approximately 9000 tons, was launched in January.

By adopting pressure charging for its two stroke engines the builders state that with the existing cylinder sizes a continuous service power range of 4000 b.h.p. to 14,000 b.h.p. is available, for engines having four to nine cylinders, and that the higher powers represent an increase of between 30 to 35 per cent. For the actual engine on test the owners have adopted a very moderate service rating of 8000 b.h.p. at 112 r.p.m. and 7 kg per square centimetre (100 lb per square inch), which represents an increase of approximately 25 per cent compared with the earlier engine. The new engine has a firing pressure of 52 kg per square centimetre (740 lb per square inch), a compression pressure of 41 kg per square centimetre (580 lb per square inch) and a fuel consumption of 155 grammes/b.h.p./hour (0·34 lb/b.h.p./hour), with the blowers running at 5500 r.p.m. and weighs 480 tons.

Except for the replacement of the positive displacement blowers by exhaust gas turbo-blowers and other adjustments the specification of the engine remains substantially the same, so that the overall advantages, compactness and simplicity of the eccentric type engine, are not impaired. Our sectional drawing shows the disposition of the turbo-blowers and, in addition, there are two illustrations of the engine, one showing the blowers mounted on the port side and the other giving a view of the starting platform. The general arrangement is in accordance with the builder's usual practice, permitting components such as crankshaft main bearings and connecting-rod bottom end bearings to be simple in form. The bedplate, frames and scavenge belt entablature are of welded steel construction, with the bedplate being of shallow pattern, as required by the owners, and incorporating a Michell thrust block, while the longitudinal members are supported on strong seats arranged on the tank top.

Both pistons are in two parts, consisting of a nodular cast iron flanged piston ring carrier and a crown of heat-resisting steel. Nuts fitted on steel studs in the crown and tightened against the bottom face of the piston rod flange hold the main piston assembly together, while a similar arrangement serves to assemble the crown, ring carrier and skirt of the exhaust piston. The piston rods which enter the crankcase through a stuffing box, are connected to the crossheads by tapered ends having collar and

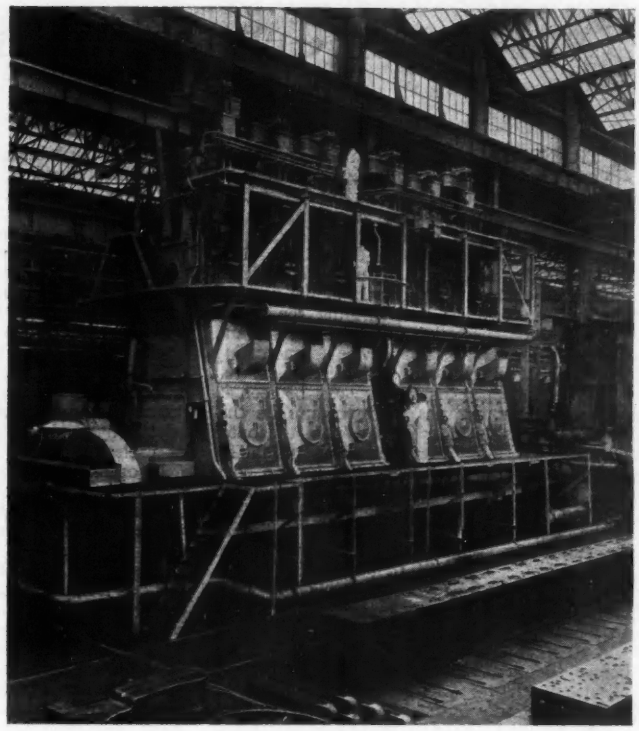


End view of engine showing disposition of blowers

nut. Large flame hardened crosshead pins are fitted and the crossheads, machined from steel forgings, have cast steel guide shoes bolted to them. Cast iron guide plates bolted to the engine frames take the ahead guide thrust and bars bolted to the ahead plates take the astern thrust. The connecting-rods are of standard construction, having forked top ends and "T"-shaped bottom ends. To the cast steel yoke, bolted to the upper part of each exhaust piston, two pairs of rods are attached, one forward and one aft, and the pairs of side rods are connected to crossheads located one on each side of the main guide. Each of these crossheads is linked by an eccentric rod with an eccentric on each side of the associated crankpin. The eccentric sheaves and balance weights are cast integrally with the cast steel crankwebs into which are shrunk the forged steel crankpins and journal pieces to form a fully built crankshaft which is short and stiff.

The cylinder liners which are of bolted construction, consist of upper and lower parts of vanadium cast iron and a centre section of cast steel containing the two fuel valves, starting valve and safety valve. Ports in the bottom section admit air from the scavenge belt and ports in the upper portion lead to the exhaust belt. The crankcase is completely closed with large inspection doors incorporating pressure relief valves. The main bearings are of white

Engine showing the two exhaust gas turbo-blowers on port side



Engine showing the controls

metal on a steel backing and there is forced lubrication throughout, part of the oil being used for piston cooling purposes, the oil being supplied at 20 lb per square inch through telescopic pipe assemblies. Fresh water cooling is employed for the cylinders, the outlet temperature being about 120 deg. Fah. There is a Wilson and Kyle gas-compression operated fuel pump for each cylinder, and the same company supplied the fuel valves which are automatically adjusting and open at 3200 lb per square inch for starting and during running the pressure builds up to a maximum of 6000 lb per square inch.

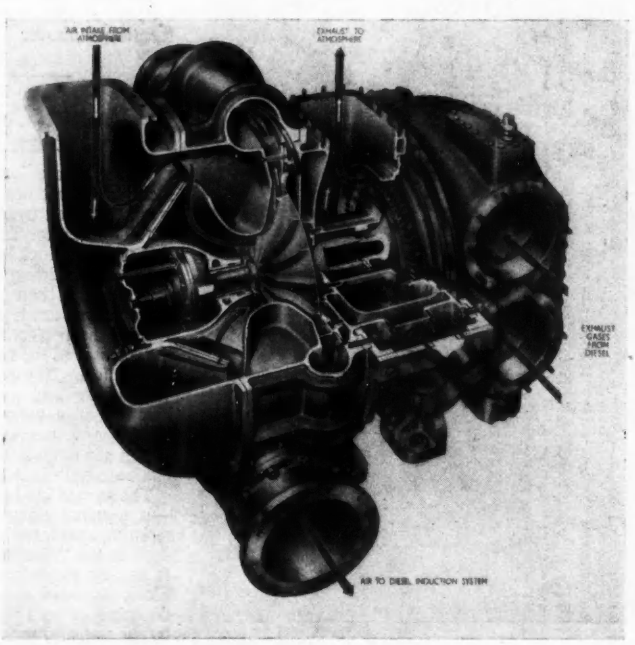
Two Napier "M.S.600" turbo-blowers, mounted on the back of the engine, supply the scavenge air, there being one blower to three cylinders. Each operates on the pulse system in which it is necessary to design the volume and area of the exhaust pipes so as to avoid pulse interference and to obtain the maximum energy from the exhaust gases. The turbo-blower, illustrated herewith, consists of four casings bolted together to house a single stage axial flow turbine and centrifugal air compressor mounted on a common shaft. The turbine casings are water cooled and connected to the main engine cooling system. The rotor assembly is carried in plain sleeve white metal bearings which are pressure lubricated with oil at 40 lb per square inch and 80 deg. Fah., the oil outlet temperature being about 100 deg. Fah. Each blower is trunnion mounted so that for overhaul purposes all that is necessary is to disconnect the feet and distance piece, then the blower can be swung through 90 deg. and lifted vertically. The main performance data for this mark of blower is as follows: maximum continuous speed, 6400 r.p.m.; pressure ratio 1·5 : 1 and sea level delivery pressure 7·35 lb per square inch gauge (0·52 kg per square centimetre); the corresponding maximum data for one hour are 7360 r.p.m., 1·7 : 1 and 10·3 lb per square inch (0·72 kg per square centimetre). The maximum turbine inlet temperature is 1200 deg. Fah. (650 deg. Cent.), and the free air capacity is approximately 11,100 to 17,250 cubic feet per minute.

Each turbine is driven independently by the exhaust from three cylinders, the exhaust gas temperature being approximately 840 deg. Fah. and its temperature on leaving the blower being 680 deg. Fah., and is therefore available for use in an exhaust gas boiler.

Air is drawn from the engine-room into the blower through a combined silencer and air filter, fitted with filter panels which may be removed for cleaning while the blower is running, and is delivered from the compressor through a Serck cooler, which cools the air from 125 deg. to 60 deg. Fah., to the scavenge air manifold at a pressure of 4·5 lb per square inch.

To maintain the blower output under slow-running conditions, when the temperature and pressure of the exhaust gases are low, the owners have had fitted a 10 h.p. d.c. electric motor which is automatically energised and engaged with the blower shaft through an air-operated clutch at speeds below 1800 r.p.m. This item of equipment forms no part of the engine builder's standard specification. As each motor is started two solenoid valves are actuated, one of which opens the lubricating circuit to the motor bearings and the other admits air to the clutch so that the motor drives the blower rotor shaft. This the motor continues to do until the engine exhaust gases are able to drive the blower at a speed in excess of 1800 r.p.m., at which point a tacho-generator generates enough voltage to operate a relay which cuts off the power supply to the motor and closes the solenoid valve in the air line, so that the clutch is disengaged. The lubricating oil to blower and motor is supplied by two pumps, one working and one standby, and there is a gravity feed system to the blower for the run down period.

During the shop trials the engine was notched down to run comfortably at 23 r.p.m. with the electric blower motor clutched in, while without the blower motors operating the engine ran at 50 r.p.m. Tests also demonstrated that the starting air serves to drive the blower so that the engine starts easily with the electric motor uncoupled from the turbo-blower.



Napier "M.S. 600" turbo-blower

CENTENARY OF ALUMINIUM.—We are informed by the Aluminium Development Association that the aluminium industry is to present a Progress Exhibition at the Royal Festival Hall from June 1st to 11th. The purpose of the exhibition is to celebrate the centenary of aluminium, to show the progress since 1855, and to illustrate the research and development completed in the past ten years. There will be five sections, the first will be historical and trace the story of the early scientist up to the discovery of present-day alloy, and the second will deal with research. The third section will demonstrate production and fabrication methods and the next will be concerned with present-day uses, while the fifth section will examine the future of the metal.

Transfer Centreless Grinding Installation

A TRANSFER line for the centreless grinding of cast iron valve tappets has been developed by Arthur Scrivener, Ltd., Tyburn Road, Birmingham, to grind automatically 2¼in long by ⅞in diameter tappets received straight from the foundry to a tolerance of ±0·00025in. This installation has an automatic initial feed hopper, centralised control from a panel at the head of the line, a conveyor line carrying the pieces through three successive grinding throats, and a push-button micro-sizing device for actuating the wheels of all three centreless grinders.

The feed hopper for the line can be seen in one of the photographs we reproduce on this page. It consists of a shallow pan, the outer side of which slopes towards a rising and falling feed blade. This feed blade has its top edge set at an angle, so that tappets picked up as it rises from the hopper roll off the edge at the top of the stroke on to a conveyor chain leading to the entry of the first set of grinding wheels. The hopper is designed to handle workpieces from ¼in to 1¼in diameter, and adjusting strips at the side of the conveyor belt can be set in accordance with the size of work being ground.

A rotating star wheel set above the conveyor before the first grinding position in the line rejects any tappets which might be superimposed upon another or resting in a vertical position on the conveyor. The pieces which pass in line beneath the star wheel then pass under a pressure roller which applies a frictional grip. This pressure roller ensures that the pieces reach the grinding throat of the first grinder in an unbroken line, and it imparts sufficient pressure behind the line to ensure that the leading piece is gripped between the control wheel and the grinding wheel.

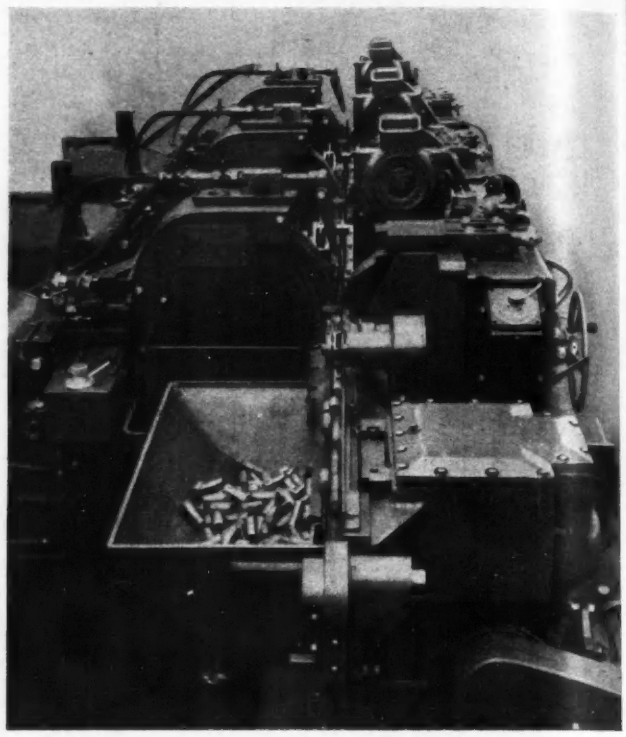
After leaving the first pair of wheels the pieces are transferred to the second set by another independent conveyor system which also comprises a chain belt, adjustable steel guides and pressure roller drive. Another similar conveyor is interposed between the second and third sets of wheels. In this final stage, in view of the high surface finish required on the pieces, the chain belt is replaced by a leather-faced nylon belt and the guides are made of "Tufnol" instead of steel.

The installation has a particularly convenient system of push-button micro-sizing applied to the control head of each grinding unit. As wheel wear commences on any grinding wheel, resulting in pieces at that stage being ground slightly over size, pressure of the appropriate push button advances the workplate and the control head to compensate for wheel wear. The distance advanced by each operation of the push button may be any required increment from 0·0001in to 0·0005in. The exact amount of the feed increment required is preselected by manipulation of a selector knob.

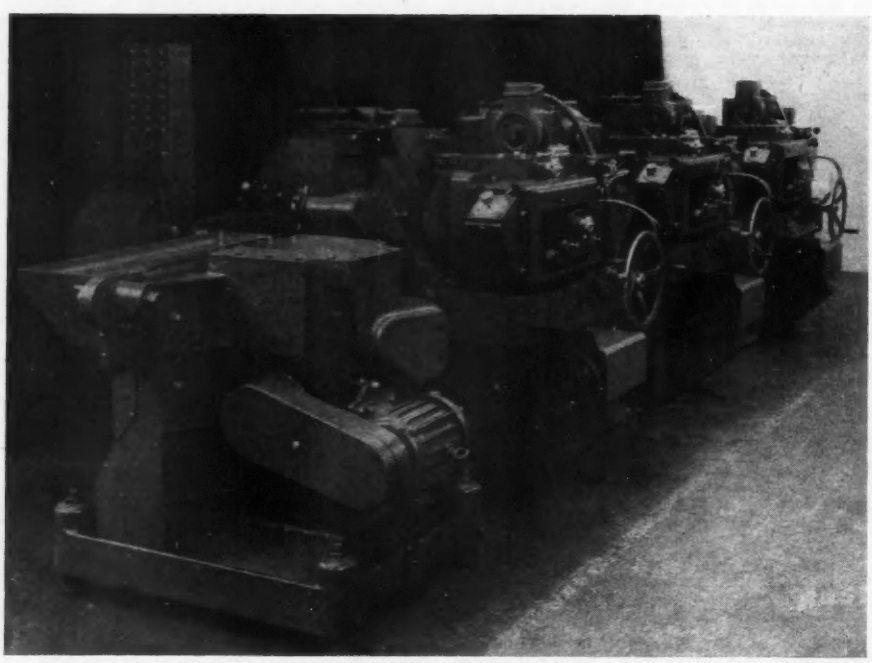
In order to maintain a smooth and uninterrupted feed through the whole line, each of the three grinding units is arranged to feed the work at a slightly faster rate than its predecessor in the line. This prevents any build-up of work on the conveyors, which would interfere with the correct rate of flow. For this reason, the control wheel of each unit is arranged for an infinitely variable speed drive from a variable-speed a.c. motor.

The coolant system has received particular attention because of the high surface finish required for this class of work. The used coolant from each pair of wheels is discharged into a common conduit, which carries it to a separate receiver at the end of the line. From this receiver the coolant is pumped into a magnetic clarifier, where revolving magnetic discs abstract all the swarf and most of the broken abrasive. From the clarifier, the purified coolant flows back into a single main storage tank from which a motor-driven pump distributes it to all three grinding units.

The panel from which the installation is controlled is conveniently located alongside the feeding hopper. This panel carries a series of start and stop buttons with a lamp alongside each to indicate whether this particular unit is working or not. Separate buttons are provided for the three grinding wheels, three control heads, hopper, the first conveyor, the second conveyor, and the coolant clarifier, so that the operator can supervise the working of all the units without moving from his station The installation illustrated is designed for a normal output of 850 tappets an hour to the limits mentioned above.



Hopper feed end of transfer centreless grinding line for tappets

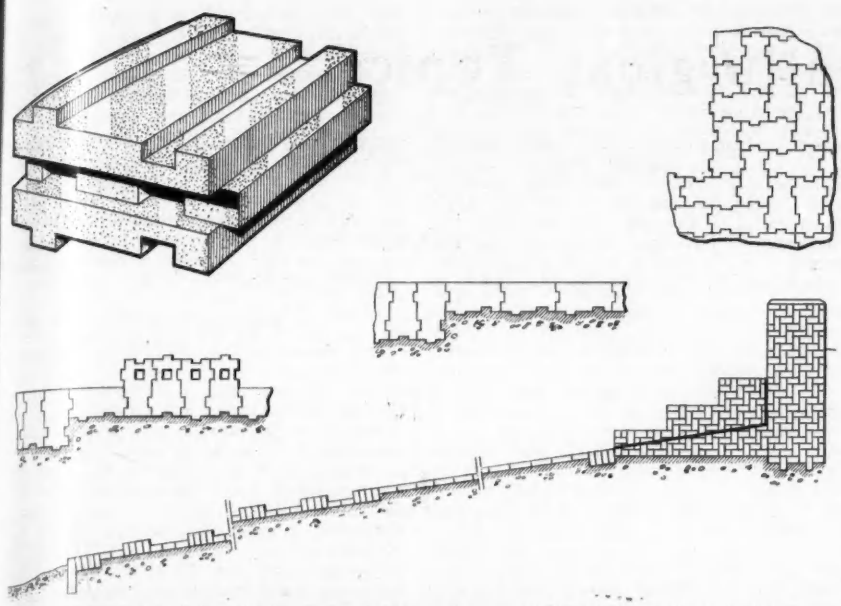


Transfer centreless grinding installation with centralised control, hopper feed and push button operated micro-sizing

Precast Concrete Blocks for Coast Protection

WE illustrate herewith two kinds of interlocking precast concrete blocks for sea defence works, evolved by Associated British Industries, 28, Chapel Street, Liverpool, 3. The first illustration shows a block known as the "Sealock" unit, for use in building revetments. Rows of blocks are laid with their plane sides in contact; succeeding rows are laid offset at half-block spacing, so that the projecting ledges of one row fit into the recesses of the next, as is clearly shown in our illustration. These blocks are 12in by 12in by 4in in size and are machine pressed, or cast inverted on a vibrating table. The "Sealock" blocks are, we understand, being tested by Dutch sea defence authorities, and a trial length has been built in Holland.

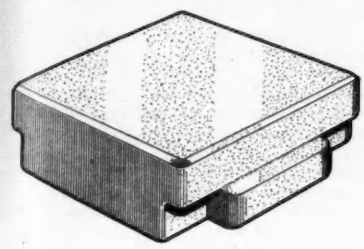
The second kind of block—the "Stormfender"—is a more comprehensive approach to wave-resisting structures, as well as plain revetments, such as the "Sealock" units would be used for. It can be manufactured as a solid or a cavity block (the cavity block is shown in the isometric diagram) or with ribbed, grooved or plain facing, by the use of standard cores and profile plates as part of the equipment at the casting yard. The blocks are 12in by 12in by 6in in size, with ½in

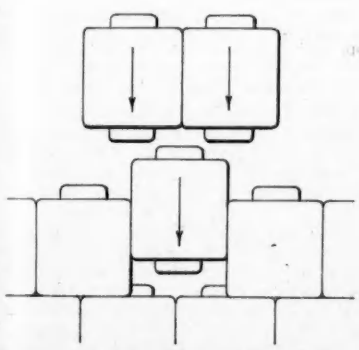


General-purpose interlocking block. The various suggested uses of the block are shown in the cross section of a hypothetical revetment and sea wall

ribs and grooves on the upper and lower faces in the fully developed shape as illustrated.

Our second illustration shows an idealised revetment of "Stormfender" blocks, arranged to illustrate some of the properties claimed for them. Revetments of precast blocks in sea defence works are often laid within a framework of beams, so that any damage which occurs is likely to be confined to one "panel," scouring action being prevented from spreading by the framework. Such a framework is here shown





Precast concrete block for coast protection. The method of interlocking is shown

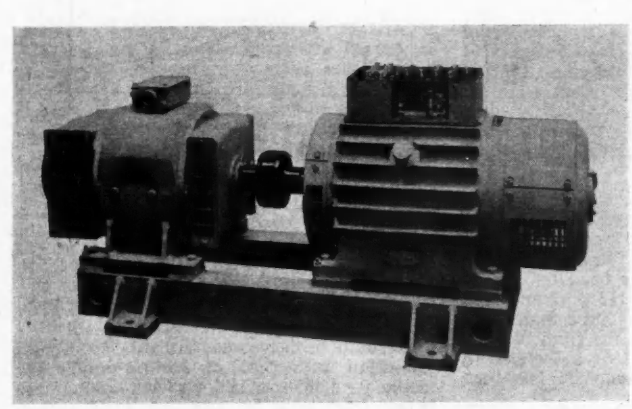
formed by the blocks themselves with several solid blocks laid vertically in place, and extending below, but locking with, the revetment itself, which is formed of blocks laid horizontally with plane top surfaces and ribbed under surfaces, as shown. Hollow blocks are also shown laid vertically, but projecting upwards to form a break in the surface to reduce wave action. An assembly of the blocks is also shown in plan, illustrating different ways in which the blocks can be fitted together to cover a surface. Our illustration also shows a complete sea wall at the landward side of the revetment, which, it is claimed, can be successfully constructed of these blocks. The stepped face, to the left of the heavy dividing line, consists of cored blocks with the cavities facing seaward. It is claimed that the pierced surface presented by this construction should absorb the shock of wave action, in a manner which it is thought will be more effective than the "solid" resistance of a conventional sea wall. Solid blocks are, however, intended for the body of the wall, behind the shock-absorbing hollow blocks.

Amplidynes for Instructional Purposes

A SPECIAL form of amplidyne intended for instructional purposes in universities and technical colleges has been developed by the British Thomson-Houston Company, Ltd., Rugby. The new amplidyne is of the same general construction as its industrial counterpart but is provided with a special terminal board to facilitate changes in the winding connections.

It may be recalled that the amplidyne (as described in B.T.H. Patent No. 539,835) is a "cross-field" d.c. generator having a quick response, together with a high ratio of output power to field power. As such it has many applications as an auxiliary exciter for equipments requiring accurate and automatic control. The number and design of the control fields of an amplidyne depend on the particular application. In the instructional machine, therefore, the fields have been designed so that the amplidyne may be used in a variety of ways. All leads from windings and brush-gear are brought out to separate terminals arranged in a diagrammatic layout on the terminal board, and a set of links is provided for making the normal amplidyne connections. A tapping is provided in the compensating winding so that the operation of an under-compensated "constant-current" machine may be demonstrated, and a diverter resistor is also provided to allow fine adjustment of compensation over a small range.

The instructional machine is available in two frame sizes, with the following ratings: type "CXX.3024," 2 poles, 1410/1500 r.p.m., 220V, 3·6A, 0·8kW; type "CXX.4124," 2 poles, 1430/1500 r.p.m., 200V., 12·5A, 2·5kW. The amplidyne is usually supplied on a base plate, driven through a quickly-detachable flexible coupling by either an a.c. or d.c. driving motor of standard industrial design; the equipment illustrated here is a "CXX.4124" amplidyne driven by a d.c. motor.

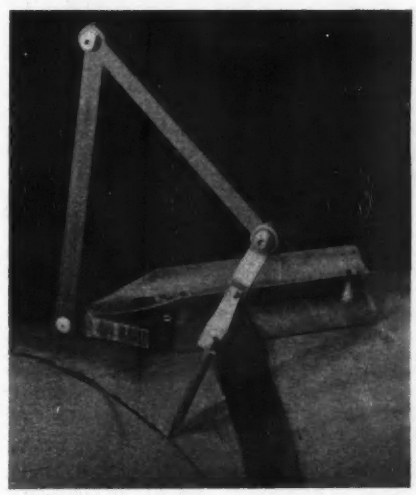


Amplidyne set designed for instructional purposes. Connections to demonstrate amplidyne characteristics can be made by changing links on the terminal board. A tapping is provided in the compensating winding so that the operation of an under-compensated "constant-current" machine can be demonstrated

Marking-Out Tool for Pipework

A CONTOUR marker which permits the marking out of curves of interpenetration on pipes has been put on the market by Rediweld, Ltd., 15–17, Crompton Way, Crawley, Sussex.

As the accompanying illustration shows, the instrument consists of a body made from two U channels arranged back to back. At one end is a protractor, which carries a linkage fitted with a crayon point. The setting of the protractor defines the plane in which the crayon moves in relation to a reference plane either containing the pipe axis and the axis of the instrument, or at right angles to the pipe axis. The marker, which can be held or strapped to the pipe, is self-aligning for diameters up to about 8in. It is suitable for pipes from 1in to 18in diameter, and the firm states that a larger version, for pipes of 16in to 48in diameter, will become available in a few months' time. It is claimed that the instrument eliminates the use of precut patterns or templates. For elbows and equal Y-joints the marker gives the correct solution, while saddle joints between pipes of unequal diameters can be marked out to a sufficient degree of accuracy. Allowance can be made for the wall thickness in cases where the cut is not all in one plane.

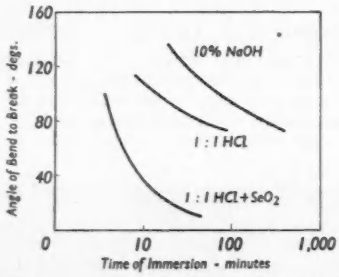


The contour marker is held or strapped to the pipe in alignment with the axis. A protractor and linkage-mounted crayon permit the lines of intersection with the repaired cutting plane to be marked on the pipe

Metallurgical Topics

Hydrogen Embrittlement of 12 Per Cent Chromium Steel

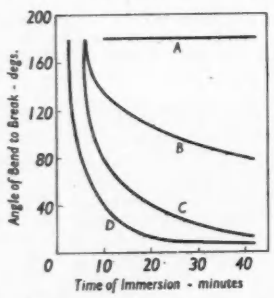
REDUCTION of ductility and fatigue resistance, sometimes leading to failure by cracking, may occur in 12 per cent chromium steel as a result of hydrogen embrittlement. Such failures are usually due to surface corrosion whereby hydrogen is released and diffuses into the metal. To explore this effect, several 12 per cent chromium steels (carbon 0·06 to 0·13 per cent) were tested by A. E. Durkin* under various conditions. Electrolytic pickling in 10 per cent NaOH solution was used to produce hydrogen



Heat treatment, 955 deg. Cent., 20 minutes; 482 deg. Cent., 2 hours ; hardness, R_c 44 to 46.

Fig. 1—Embrittling power of several solutions at varying times of immersion of samples of 12 per cent chromium steel (Durkin)

gas without attacking the metal, and hydrochloric acid solutions to show the combined effect of hydrogen, metal attack and acid impurities. The steels, after different tempering treatments, were subjected to the action of both caustic and acid solutions. A constant-rate, single-bend test of the k nd described by C. A. Zapffe† was employed. (Zapffe's test involved a special mechanism intended to bend a 0·06in diameter wire round a 0·06in radius in a single bend at a constant rate of 5 deg. bend per second.) The results reproduced in Fig. 1 relate to the steel tempered at 482 deg. Cent. (Rockwell hardness, C44 to 46). The ductility measured



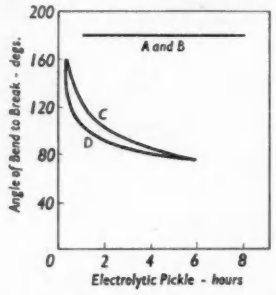
	Treatment (deg. Cent.)	Hardness (R_c)
A ...	... 955 deg., 20 minutes, 610 deg., 2 hours	... 23 to 25
B ...	... 955 deg., 20 minutes, 550 deg., 2 hours	... 30 to 33
C ...	... 955 deg., 20 minutes, 532 deg., 2 hours	... 37 to 40
D ...	... 955 deg., 20 minutes, nil	... 43 to 46

Scale not removed.

Fig. 2—Effect of immersion in 1 : 1 HCl+SeO_2 on 12 per cent chromium steels of different hardness (Durkin)

by angle of bend decreased considerably but the effect of the acid solutions was more severe than that of caustic soda. After a forty-minute immersion in 1 : 1 HCl, the bend to fracture was 80 deg., in caustic soda 113 deg., and both approached 70 deg. after prolonged immersion. The addition of selenium in the form of SeO_2 to the hydrochloric acid led to a decrease to 10 deg. Acid containing sulphide has been found to exert a similar effect.

In lower hardness ranges, i.e. after tempering at a higher temperature, samples were less susceptible to embrittlement. This was shown in both kinds of solution. After being tempered at 593 deg. Cent., the steel immersed in 1 : 1 HCl+SeO_2 showed no embrittling tendency up to 180 deg. bend, the limit of the test. After no tempering or treatment at lower tempering temperatures, the angle of bend to fracture progressively diminished as the hardness increased (Fig. 2). The same applied, but to a

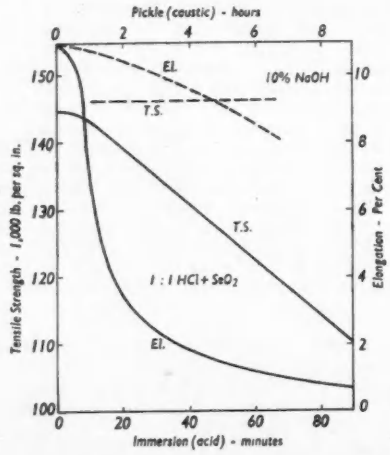


Treatment and hardness as under Fig. 2. Scale removed.

Fig. 3—Effect of electrolytic pickling in 10 per cent caustic soda solution on 12 per cent chromium steels of different hardness (Durkin)

lesser extent and after more prolonged immersion, to specimens electrolytically pickled in caustic soda solution (Fig. 3). In this case, specimens tempered at 550 deg. Cent. also showed no embrittlement which would bring the angle of bend below 180 deg. The higher the tempering temperature and the softer the steel, the less was its susceptibility to embrittlement in either solution.

Additional samples were treated in both acid and caustic solutions for times up to ninety minutes in one case and six hours in the other, and the tensile strengths and elongations were determined (Fig. 4). In the acid solution there was a decrease in both ductility and tensile strength as the time of immersion was increased.



Heat treatment, 955 deg. Cent., 20 minutes, 538 deg. Cent., 2 hours

Fig. 4—Tensile strength and elongation of 12 per cent chromium steel after treatment in acid and caustic solutions (Durkin)

The tensile strength fell from 144,000 lb to 110,000 lb per square inch (64·3 tons to 49·1 tons per square inch), and the elongation from 11 to 1 per cent. After treatment in caustic soda solution there was a slight decrease in elongation with time of treatment, but the tensile strength remained unchanged up to six hours.

Twelve samples of the steel were subjected to an alternating stress of 24·5 tons per square inch. The steel in its original condition failed after fifty-seven minutes while the embrittled samples averaged only eight-and-a-half minutes before failure, indicating that hydrogen had a serious effect on the fatigue characteristics.

Hydrogen, produced in pickling processes, can thus definitely affect the properties of 12 per cent chromium steel adversely, but hydrogen embrittlement is much reduced or eliminated if the steel has been tempered in the temperature range 550 deg. to 600 deg. Cent.

Induction Heating

THE discussion on "Induction Heating," which took place at the American Society for Metals National Metal Congress, held at Chicago on November 3rd, 1954, revealed the extent to which induction heating has received new applications, aided by recent improvements in equipment. Contributions to the discussion are reported in *Metal Progress*, November and December, 1954.* The use of high-frequency alternating currents for heating metals was proposed by E. F. Northrup in 1917. After the introduction of the high-frequency melting furnace in the following year, suggestions were made for the use of induction hardening in heat-treatment operations ; but it was not until 1935 that the equipment for the first of such applications, viz. the surface hardening of steel, was available commercially.

INDUCTION HEATING FOR SURFACE HARDENING

During the following years the patented Tocco induction heating process became widely known. It had distinct advantages over the surface hardening methods generally adopted at that time, in speed, cleanliness, reduced distortion and control of depth of hardening. Local hardening could be applied when desired to specific surfaces subject to wear without the necessity of "stopping off" regions not to be hardened. Material could be machined in the soft condition, and the surface hardening applied as a final operation which was completed in a few seconds. Standard examples of the use of surface hardening by induction heating are crankshafts, camshafts, sprockets and gear teeth. Specially designed coils are required for each part but the basic high-frequency equipment is common to all. High capital costs militated against its more general use, but more recently the demands for mass production have reduced the importance of this factor. A combined operation of machining and hardening can be made fully automatic by reserving one spindle of a multiple-spindle automatic machine for the induction coil and the heat-treating operation.

INDUCTION HEATING FOR FORGING

The induction method is also well adapted to heating for forging operations, and in this connection was first used in heating for upsetting of bars and tubes. One end of a bar could be heated uniformly to the forging temperature so rapidly that the adjacent part remained cool. It is in the heating of billets of steel and of non-ferrous metals for forging or extrusion that the applications of induction heating have undergone the most rapid extension ; and here the question of the choice between high or low frequency arises. The choice is in part governed by economic motives because high-frequency costs more per kilowatt, but there are other important considerations. Low frequency gives a greater depth of penetration of the induced current. The heat is generated near the surface and flows by thermal conduction towards the centre. A soaking time must be allowed for equalisation of temperature, but the increased penetration produced by low-frequency current results in more rapid heating of the larger pieces. The largest 60-c/s heater described in the discussion was one which handles 20in billets of aluminium, up to 65in long, and serves an 8000-ton extrusion press. Several vertical heaters were reported to be under construction for the U.S. Air Force heavy press programme. They will preheat

* *Iron Age*, December 9, 1954, page 154.
† *Wire and Wire Products*, May, 1947, page 351 ; July, 1948, page 563.

* Papers by H. B. Osborn, jun., November, page 125 ; F. T. Chesnut, December, pages 91 and 98 ; J. A. Logan, December, page 94 ; and C. P. Bernhardt, December, page 102.

aluminium ingots up to 32in diameter and 70in long, weighing nearly 3 tons. The ingot, which would require fourteen hours in a fuel-fired furnace, is heated from room temperature to 450 deg. Cent. in thirty minutes. In this manner, also, a 15in ingot of magnesium can be heated to extrusion temperature in eight minutes. Heating is done in three stages at different rates in each, and allows for soaking between to equalise the temperature. Transfer from one stage to the next is automatic. Some 100 installations have been set up in America to deal with the extrusion of aluminium since 1948. The brass industry has not adopted induction heating to the same extent ; but there has been great expansion in its use in the steel industry, particularly in forging plants, and also in connection with steel extrusion and the rolling of alloy steels.

An important consideration in the induction heating of iron and steel is the large decrease in permeability which occurs at Ac_3 (about 760 deg. Cent.). Above this temperature the magnetic field penetrates much deeper, with consequently increased depth of current penetration. In the mass production of fairly heavy steel parts low frequency is favoured for heating to Ac_3 and high frequency for further heating to the forging temperature. As already indicated, 60 c/s frequency is desirable for large billets (6in and over), whilst for small billets high frequency has the great advantage of speed. Thus, for bars smaller than 1¼in diameter, or larger than 6in, dual frequency will not ordinarily be justified economically. It has been applied to feed two presses making 81mm mortar shell. There are four units in parallel. Each unit discharges one billet every ten seconds at 1230 deg. Cent. with a surface to centre difference of about 27 deg. This is equivalent to a production of the four heaters (two presses) of 1440 shells per hour. The billets are progressively fed through the 60 c/s coil section, and the 960 c/s coil section of the induction heater, and then discharged into a trough from which the billet is removed by the operator to the press immediately adjacent. A larger installation of continuous-feed, dual-frequency forging heaters is reported as now going into service for the production of 105mm shell. Two separate rows of billets, as they are pushed through the heater, 35ft long by 5ft wide, are heated to Ac_3 by two 60 c/s coils, and then to the forging temperature by two 960 c/s coils. In each heater 3·5in round-cornered square billets, 8in long, are heated to 1175 deg. Cent. at the rate of 480 per hour. It would appear that dual frequency heating may assume an important, though limited, role as an efficient method and one which offers substantial economies in first costs and in operation.

Properties of Slack-Quenched Steels

A SLACK-QUENCHED steel may be defined as one of which the microstructure contains decomposition products of austenite formed at temperatures above M_s, the temperature at which the austenite→martensite transformation starts to take place. Owing to mass effect it is impossible to avoid a certain degree of slack quenching in the treatment of very heavy forgings. A small amount of slack quenching can be tolerated without any adverse effect on the mechanical properties, and in fact is preferable to the risk involved in drastic quenching. In fully hardened and tempered steel of different compositions there is much less difference in mechanical properties at a given hardness than in slack-quenched steels of the same compositions. To avoid having to deal with heavy forged steel sections, and to reduce the study of the slack-quenched condition to more manageable proportions, J. Vajda and P. E. Busby* devised a method of reproducing the slack-quenched structures obtained in heavy forgings by end-quenching a cylinder, 7in diameter and 7in long, which had been heated to a uniform temperature of 870 deg. Cent. Before treatment the cylinder was partially cut through longitudinally to facilitate sectioning in the hardened condition, but the quenched face was left intact. After end quenching, the longitudinal sections were tested for hardness and then tempered at temperatures between 540 deg. and 615 deg. Cent. Transverse tensile tests and notched-bar impact tests were made on the tempered sections at different distances from the quenched end. The types of steel used were mainly 2·5 : 1·0 : 0·4 nickel-chromium-molybdenum with carbon about 0·22 per cent and low nickel-chromium-molybdenum with carbon 0·33 to 0·41 per cent. After an initial fall near the quenched surface the tensile strength throughout the slack-quenched region was fairly constant, but the yield strength showed either a progressive fall or, when the hardenability was less, a rapid fall to a fairly constant value. The hardness tests taken before tempering showed that steels placed in order of hardenability by the Jominy test did not always maintain that same order when end-quenched in the large section. The advantage of boron additions revealed by the Jominy test appeared to be lost in the heavy section. The transition temperature in the impact test was progressively raised by the presence of increasing amounts of slack-quenched structures. In a 0·4 per cent carbon low-alloy steel, boron seriously lowered the impact value when the steel was slack-quenched, though it was without detrimental effect in the low-carbon steels. The addition of rare-earth metals had little or no effect on the hardenability or on the mechanical properties of the slack-quenched structures.

Vajda and Busby† have extended their tests to cover other compositions, mainly low nickel-chromium-molybdenum steels with increased nickel (up to 1·58 per cent) or silicon (up to 1·37 per cent). They confirmed the conclusion that, at a given hardness, boron lowered the transverse impact value of the slack-quenched structures and rare-earth metal additions to a boron-treated steel had a further small detrimental effect on transverse reduction of area and impact value. Addition of silicon improved the properties near the quenched end, but in the slack-quenched region 1 per cent of silicon lowered the transverse reduction of area and impact value. Raising the nickel from 0·5 to 1·5 per cent in the low nickel-chromium-molybdenum steel improved the impact value of the slack-quenched structure without affecting its tensile properties.

In conclusion, Vajda and Busby pointed out that the applicability of results obtained on end-quenched 7in rounds that had been slotted might be called in question on the grounds that, although cooling rates may approximate to those at equivalent distances from the surface of heavy forgings, the stresses induced are relatively low, whereas transformation and cooling stresses may be high in the large mass of a forging. Many believe that these stresses significantly affect the formation of various decomposition products of austenite and so influence the mechanical properties in such a manner that they cannot be predicted from results obtained on small masses. It would appear, however, that tests on end-quenched specimens of the type described can give a good indication, at least of the trend, of the properties of a slack-quenched structure, and that the properties of a large forging are likely to be, if not the same as, at least no better than, those at equivalent positions in the massive end-quenched bar.

Steels for High Temperature Steam Pipes

THE choice of a particular steel for use as steam pipes presents a complex metallurgical problem to the designer who has to hold a balance between economic considerations, fabrication and constructional difficulties which may impose limits on outside diameter and wall thickness, and the essential requirement of withstanding the design pressure at the operating temperature throughout the expected service life of the installation. The main factors governing the choice of steel were very clearly indicated in an article by Dr. J. M. Robertson in the December, 1954, issue of the *Alloy Metals Review*.‡

No great difficulty arises until operating temperatures exceed 400 deg. Cent. Below this temperature carbon steel tubes will give satisfactory service. At higher temperatures, the resistance of the steel to creep becomes an over-riding factor. A very large amount of creep testing has been carried out on a wide variety of steels which may be suitable for steam pipes, but the correlation of the results is difficult on account of the different conditions in which the tests were made. The most trustworthy data are being assembled by the technical committee ISE/8 of the British Standards Institution. Even when definite information is available, there is some difference of opinion as to the criterion upon which design should be based, whether 0·1, 0·2 or 0·5 per cent of creep in 100,000 hours, or some percentage of the estimated minimum stress to rupture in 100,000 hours. Few creep tests have been made to 100,000 hours, and by using different data different estimates of the 100,000-hour properties may be made. The trend, however, has been to use low-alloy steels of increasing alloy content as the operating temperature increased. A carbon-molybdenum steel (carbon 0·12, molybdenum 0·5 per cent) was the first developed to meet conditions which the carbon steel could not withstand. In view of American experience of graphitisation (reported fully during the last decade in the *Transactions* of the American Society of Mechanical Engineers, and attributed to the effect of aluminium used for deoxidising) great care is needed in the deoxidation of this steel. To obtain further improvement in creep properties and to resist graphitisation, chromium was added, giving the widely used chromium-molybdenum steel (chromium 1·0, molybdenum 0·5 per cent) or the less widely used chromium-molybdenum steel with higher alloy content (chromium 2·25, molybdenum 1 per cent). The higher alloy content of this steel is, perhaps, not justified by the slight improvement it shows in creep resistance, and better results are obtained by the use of steel which undergoes precipitation hardening, such as molybdenum-vanadium steel (molybdenum 0·5, vanadium 0·25 per cent) or molybdenum-vanadium-titanium steel (molybdenum 0·5, vanadium 0·25, titanium 0·2 per cent). The latter has not yet been used for steam pipes, though it would withstand a higher stress than molybdenum-vanadium steel at working temperatures up to about 560 deg. Cent. On the basis of creep resistance, it could be used at temperatures up to 600 deg. Cent. but above 570 deg. Cent. an additional factor, resistance to corrosion, becomes important. To guard against excessive oxidation, the choice again reverts to steels of higher chromium content. Possibilities which have proved themselves in other fields are a 6 per cent chromium steel containing molybdenum 0·8, tungsten 0·5 and titanium 0·2 per cent, or an 11 per cent chromium steel containing molybdenum 0·6, vanadium 0·3 and niobium 0·25 per cent ; but the only high-chromium steel actually used for steam pipes in 600 deg. steam turbine plants is the austenitic steel containing chromium 18, nickel 12 and niobium about 1 per cent. This steel has excellent resistance to oxidation, but mechanically is unsuitable for use above 600 deg. Cent., i.e. about 30 deg. higher than the useful limit of molybdenum-vanadium steel. There are other austenitic steels with greater resistance to creep and oxidation, but no demand for them has so far arisen. Meanwhile, however, it is to be hoped that the suitability of the high-chromium ferritic steels for use in high-temperature steam pipes will be further explored.

Dr. Robertson's article is of great interest in outlining the present position and in clearly defining some of the factors which are of importance in the manufacture of steam pipes for high-temperature service.

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* *Transactions, American Society for Metals*, 1954, Vol. 46, page 1331.

† American Society for Metals, Annual Convention, 1954, Preprint No. 24.

‡ High Speed Alloys, Ltd., Widnes, Lancs.

SECOND INTERNATIONAL CONGRESS OF PRESTRESSING.—The International Federation of Prestressing is to hold its second congress at Amsterdam, from August 29 to September 2, 1955. The principal subjects to be discussed at the congress are to be as follows : the influence of grouting and anchorages on the behaviour of prestressed elements ; the use of steel for prestressing ; precast, prestressed work ; moment distribution in statically indeterminate structures beyond the elastic phase ; the influence of plasticity on the strength and stability of prestressed thin shells ; specifications and codes of practice for prestressed concrete in various countries, and the economic advantages of prestressed concrete in various countries. A programme of visits is also to be arranged. Further details may be obtained from the Prestressed Concrete Development Group, 52, Grosvenor Gardens, London, S.W.1.

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ACADEMIC KNOWLEDGE AND INDUSTRIAL PRACTICE

Comparisons are proverbially odious. One that seems particularly odious to us is that which makes it appear that per head of its population the United States is carrying out something like seven times as much research in science and engineering as is this country. It may be so ; but the figure is quite untrustworthy. In the discussion of three short papers on "Co-operation in Engineering Research between Educational Institutions and Industry" at the Institution of Mechanical Engineers last Friday, one speaker remarked that when making such comparisons it would be wise to set the exchange rate for the pound at about 10 dollars instead of 2.80. Again, what is research ? Much of the expenditure debited under that heading in America would not, we think, be so defined here. Sponsored research across the Atlantic, we suspect, includes much work which would here be done on the works test-bed, the cost being debited to "overheads." Nor are figures, such as those presented by Mr. Nixon in his paper, showing that heavy mechanical engineering firms as a group spend only 0·7 per cent of annual turnover on research as against 2·5 per cent for heavy electrical engineering, 5·3 per cent for light electrical engineering and 2·4 per cent for chemical engineering altogether trustworthy guides either. For there is no direct connection between turnover and research costs. To obtain results from a particular research will cost a particular sum of money, whether it is sponsored by a firm with a large or a small turnover. Again, when heavy units are manufactured research expenditure may seem small in relation to financial turnover, but large in relation to the number of products manufactured. Nor should the influence of the scale of the returns possible upon investment in research be altogether neglected. In relatively new industries it may be very high indeed. Something new, with an enormous potential market, may be created, like television or a synthetic fibre. In older established industries the returns are likely to be much more modest.

But to argue that figures quoted to disparage the performance of one country or one industry against that of another are unreliable is not to claim that more than enough is already being spent on research in this country. We doubt if enough is being spent. In particular we doubt whether, now that engineering is becoming more scientific, industry is making as much use as it beneficially could of academic knowledge. Closer contact between industries and universities and colleges could benefit both. No one, we hope, is going to suggest that industry here should ask universities to undertake sponsored research on the same scale as they undertake it in America. There the situation has developed so far that universities are being driven to set up separate research "centres," whose staffs have nothing to do with teaching at all, and much of the sponsored "research" amounts to little more than routine determinations of the characteristics of particular items of industrial production, the flow characteristics of a particular valve, for example. Surely the kind of work that educational establishments should undertake for industry ought to have at least some educational content—that is, there ought to be some fundamental factors involved whose elucidation will add to the stock of theoretical knowledge ? Of course, it is true that more often than not industry is interested less in any fundamental factors that may be involved than in getting quickly results that will improve its particular manufactures. But no one can ever be certain what a line of investigation will lead to. The attempt in a works test bay or its research laboratory to improve a certain device may reveal the presence of quite unsuspected difficulties. It is then that an approach to a university or to a local college may prove helpful. The academic mind may have knowledge of useful published work about the problem ; or it may be able to illuminate the difficulty and show where the problem really lies ; or it may be able to suggest a different method of approach or indicate a new technique for the analysis of experimental results. It is often overlooked by industry that those are the quite ordinary functions of educational bodies. And, if there is an unknown fundamental factor involved the university or college is likely to be well equipped to make a research into it.

But the advantages do not all lie on the one side. The universities and colleges benefit, too, by co-operation with industry. Very often practical engineers struggling with problems of production, operation or design find much of the published works of professors and research workers incomprehensible. They fail to see from their writings how their discoveries and theories can be applied. If, as one contributor to the discussion suggested, university research was wholly confined to the fundamental that situation would be still further aggravated ! But if industries more readily consulted universities and colleges about their problems they could ensure not only that professors and research workers really maintained a contact with practicalities, but, in addition, that those researches with some fundamental content undertaken at universities and colleges were really those likely to yield results of high and more immediate value to industry. In particular, we were impressed at the Mechanicals' meeting by the method of co-operation outlined by Mr. Nixon, whereby a member of the engineering staff of a firm engaged upon a particular development project works part-time at a local university or college on the more theoretical aspects of his problems. Thereby a particularly fruitful co-operation between the academic and the practical must be created, and one which must break down that barrier which too often seems to exist, shutting off the industrial engineer from advancing academic knowledge and the professor and teacher from more practical experience.

THE COMFORT OF INEFFICIENCY

Not long ago we secured the services of a "daily help." She seemed a very "treasure." For she had a passion for orderliness and tidiness and economy. Once let loose in the home, she soon had it all clean and polished, every chair and every cushion in its place, every book returned to a shelf, all the odds and items of human activity tidied away. But—it is a sad reflection upon the reaction of individuals to her very real efficiency—soon we had christened her "The Menace." For we dared leave nothing lying about. Classified by her orderly mind, it would be stored away in some drawer or cupboard, taken to what seemed to her a more "appropriate" room, thrown out into the garden shed or even discarded to the dustbin! Once gone we never knew where to look for an article thus disposed of. We recall

that fortnight of mounting despair—we could bear the imposition no longer despite her undoubted virtues—whenever we hear engineers or others with orderly minds suggesting neat plans for the organisation of this or that or for securing a more rational usage of resources. We recalled it last Friday, at the " Mechanicals," when, during the discussion we review in the preceding article, a speaker neatly arranged research establishments in descending order of the fundamental content of the work he deemed they should undertake. We think of it whenever we see an organisational chart laying down with precision the chain of authority and limits of responsibility. The experience dwells in our minds when politicians and others express such ideas as that there should be a national fuel and power policy, eliminating competition between solid and liquid fuels, gas and electricity ; a carefully considered scheme for fixing priorities in capital expenditure ; a better organisation of research, so that " first " things will be the first investigated ; or so neat a co-ordination of road and rail transport that each would carry only those goods and passengers it was best fitted to carry.

As engineers, logical thinking about such subjects has an undoubted attraction for us. After all, our very training stresses the need to seek efficiency as a means of attaining the highest possible economy in our products and our methods of manufacturing them. It distresses us to see resources wastefully used. Seen solely as a technical problem, it does seem absurd that raw coal should be burnt inefficiently on domestic grates, pouring out smoke to pollute the atmosphere, when by proper treatment of it two smokeless fuels, gas and coke, can be produced and all its valuable by-products be recovered. Again, is it technically and economically rational to expend a lot of capital on the building of electric power stations with sufficient aggregate capacity to meet a high peak load when some of that peak load is created by electric cookers and electric fires which could be replaced, with an economy in fuel usage, by gas ? Surely it should be technically feasible to decide what traffics can be economically best carried by road, rail, canal or coastal shipping and to arrange accordingly that they shall be so carried ? With what rapidity we, as engineers, could expand the material wealth of the country if its people, engineers included, would only agree to much more standardisation which would permit simplification and specialisation to be more widely practised ! Again, if the multiplication of material wealth is to be our aim, surely it should be possible to work out a national plan of the priorities that should be assigned to capital expenditures upon the expansion of manufacturing plant, the modernisation of roads and railways, the building of ships and power stations and the construction of bridges and sewers and waterworks and houses and much else besides. For do not people desire a heightened standard of living as soon as possible ? Are not those the quickest ways to attain it ? But soft ! There is need to pause. Man does not live by bread alone. Can a standard of living be measured solely in terms of cars, television sets, washing machines, power and other material things ? For if it can then to let anyone take up the arts as a career is a waste of manpower !

The fact of the matter is that an engineer's concept of efficiency makes no appeal to human emotions. That concept is very properly applied to those products that one set of engineers designs and manufactures for other engineers to operate and maintain, like power station equipment, locomotives, cranes, dams and other structures, and many other things. But the efficient working of those products is not an end in itself. They constitute only the means through which some of the purposes of mankind can be served. Their prime purpose is not to make human life more efficient, but to make it happier. Indeed, at the level of consumption goods efficiency has little to do with the matter. The individual chooses to do, within the limits of his pocket, what to him individually seems to maintain the highest living standard. Materially he may count all else well lost, if he can but have a masterpiece above his mantelpiece ! He may accept the higher running cost of an immersion heater merely to be free from the tiresome chore of filling a stove with anthracite. Smogs and the wastage of by-products may mean nothing to him as against a preference for the open fire. What he can afford depends less upon the efficiency of the goods he buys than upon the value he individually sets upon artistic merit, comfort and convenience. Sir John Elliot can argue logically the economic merit and technical transport efficiency of banning all private cars from the streets of Central London. On those grounds his case is indeed unanswerable. But he cannot alter the very human fact that it is only existing congestion in Central London that prevents a great many more private motorists using their cars, uneconomically but nevertheless comfortably and conveniently, for a daily journey between home and office ! That it would cost them more to do so ; that there would be a technical " wastage " of fuel, would not weigh with them at all.

Now that our " treasure " has taken her household services elsewhere our home has reverted to its former comfortable and convenient, albeit uneconomic, state. The bills, it is true, are higher—the " Menace " shopped economically—but we eat what we prefer and not only what is cheapest, and we can be tidy or comfortably untidy, just as we prefer. Technically it is all very imperfect. But life has again become worth living. It has happily reverted to the comfort of inefficiency.

Literature

Engineering Dynamics, Vol. III : Steam Turbines. By C. B. BIEZENO and R. GRAMMEL. Glasgow : Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 40s.

THE book *Technische Dynamik*, by Professors Biezeno and Grammel, which was first published in Germany in 1939, is being brought out in an English translation under the title of *Engineering Dynamics*, the complete work being in four volumes. Volume III, which appeared recently, deals with the mathematical theory of certain problems in elasticity and vibration, occurring in the design of steam (and gas) turbines. The standard of the work is roughly that of a postgraduate engineering course. The subject matter is arranged in three sections dealing, respectively, with rotating discs, turbine blades, and the whirling of rotors. Methods are presented for determining the steady stresses in discs due to torsion, flexure and radial loading. Exact solutions are derived for a number of simple disc profiles, and a step-by-step method is used for arbitrary profiles. The corresponding kinds of disc vibration (torsional, radial and flexural) are then considered. In the case of discs with arbitrary profiles the frequencies of torsional and radial vibration are found by step-by-step methods, and the frequencies of flexural vibration by the Rayleigh-Ritz method.

In dealing with turbine blades the authors follow a similar plan. Expressions are derived for the steady centrifugal and bending stresses in a blade of arbitrary shape, the latter taking into account the effects of shrouding, non-rigid root fixing, and the centrifugal field. The flexural vibration of an arbitrary blade is dealt with by various approximate methods of the Rayleigh type, involving the assumption of an appropriate deflected shape, and leading to upper and lower limits for the frequency of vibration. By the choice of suitable methods the range of uncertainty can be held at an acceptably small value. Torsional vibration of turbine blades is not considered. The final section begins with the derivation of the critical speed of a single disc mounted on a shaft of negligible mass, and continues with the effects of factors such as bearing flexibility, lack of axial symmetry in the rotor flexibility, and the gyroscopic action of the disc. This simple example is then extended to the more general case of a non-uniform shaft carrying a number of discs. The section concludes with a review of approximate methods of calculating critical speeds, including the higher criticals, for use in routine calculations.

Throughout the book the effect of damping is neglected completely in vibration calculations, presumably on the principle that designers are interested mainly in avoiding resonance, and therefore require an estimate of natural frequency (which is normally little affected by damping) rather than of resonant amplitude. While this point of view is justifiable in many cases, there are examples, e.g. the effect of bearing flexibility on rotor critical speed, where the influence of damping is of considerable practical interest, and some space might usefully have been devoted to this aspect of vibration.

A warning should perhaps be given that a purely theoretical approach such as that adopted in the book does not necessarily give a complete and accurate picture of the complex vibration phenomena encountered in practice. Electronic equipment developed in recent years has provided new facilities for the experimental side of high-frequency vibration work, and it is now possible to make accurate measurements of the modes and frequencies of vibrations of the types considered by the authors. Such measurements provide a standard against which to assess the validity of the simplifying assumptions made in calculations. The value of the book would have been increased if experimental data of this kind could have been included. Considered purely from the mathematical point of view, however, the book is excellent and should prove a very useful reference for those engaged in turbine design.

OIL ENGINE AND GAS TURBINE DIRECTORY.—The Temple Press, Ltd., Bowling Green Lane, London, E.C.1, has published *The Oil Engine and Gas Turbine World Directory of Manufacturers*, price 2s. 6d. This small volume lists the design of oil engine and range of powers produced by manufacturers in most countries, and a companion list gives general particulars of gas turbines constructed by a number of builders throughout the world.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAY MOTIVE POWER

SIR,—I have read with very much interest your references to the paper by Mr. H. H. Phillips, recently communicated to the Institute of Transport, in THE ENGINEER of January 14th, and am pleased you again refer to it in your impression of January 21st. In my view the author has done a valuable service in drawing attention in a practical manner to a subject of prime importance—the utilisation of locomotive power. Over the years those responsible for the provision of motive power have largely centred their endeavours on the attainment of increased availability and with, it is only fair to say, a large measure of success, the reflection of which is seen in the relatively high mileage now made between major and intermediate repairs. Availability is, however, of little value unless it can be utilised ; the designer has, however, no responsibilities in this connection, which is entirely in the hands of the operating department. Unfortunately, the intensive utilisation of motive power on British Railways is by no means easily attained ; that is to say, generally speaking. However, Mr. Phillips has indicated how better use may be made of locomotives, and has thus taken an important step forward.

Some time back Colonel H. Rudgard, in his presidential address to the Institution of Locomotive Engineers, appealed for what he termed a "rescheduling of the schedule" in order to fit train timings to the locomotive in place of fitting the locomotive to the train. Colonel Rudgard fully realised that he had the availability but what he had not got was the utilisation factor. Now Mr. Phillips is pursuing a course previously marked out and in so doing is to be warmly commended. Clearly, before embarking into the unknown, it is up to the railway administration to explore to the full the possibilities of improving the use of present motive power equipment. It is highly probable that much can be accomplished. Since the setting-up of the nationalised railway system, steam locomotive design and testing have received probably greater attention than ever before throughout its long history of development. This work carried out by practical men of proved ability under the able direction of R. A. Riddles, a Crewe man of distinction, has met with a large measure of success when looked at from any standpoint. Moreover, comprehensive trials have indicated how these engines can be most efficiently employed, while at the same time their potential employment factor—availability—must surely be of the highest order. This work, well and patiently done over the last six years or more, must not be allowed to go for nothing. It is freely admitted that other forms of motive power are or can be made available, though how they could possibly compete commercially with the steam locomotive is entirely a very pertinent question. Here I am reminded of a valuable paper by R. G. Jarvis, B.Sc. (Eng.), read before the Institute of Fuel and the Institution of Locomotive Engineers, 1952*, in which the author firmly stated "Under present circumstances there is no practical alternative to the existing policy of working trains with the orthodox steam locomotive." The writer has followed the progress made in steam locomotive design and performance over upwards of half-a-century and, though admittedly a "steam man," is nevertheless sufficiently interested in railways here and elsewhere to appreciate other means of traction now highly developed. Even so, on mature consideration, there would appear to be little doubt that, for our conditions as at present seen, steam, if properly applied and used, is probably the only practical type of motive power available to our railway system.

Finally, I quote opinions expressed by one whom the writer holds in great respect. Speaking of comparisons drawn between different forms of motive power, it was said : "Too often is the thirty-years-old compared with the brand new and the modern steam locomotive with capacity for performance and availability infinitely superior to its predecessors held down to schedules virtually unaltered over many years, schedules which would be revised as a matter of course to ensure the best results from other forms of motive power." Thus, I end as I began, by saluting Mr. Phillips and expressing the thanks of a "steam man" for an able exposition of one of the main problems confronting the railway industry.

E. C. POULTNEY

London, N.W.3.
January 25th.

[Notwithstanding the publication last week of the British Transport Commission's proposals for electrification and the use of diesel locomotives, the "steamer" must still be used for very many years to come. This letter, written before the Commission's plan was published, is, therefore, not made irrelevant by the plan. Indeed, in its references to availability and utilisation it is as pertinent to diesel as to steam locomotives.]

LOCOMOTIVE SUPERHEATING

SIR,—May I draw your attention to the fact that the modern development of heat-resisting alloy steels has made it possible to improve the performance of the locomotive boiler ? There is little doubt that the well-known smoketube type superheater has been as successful as the boiler introduced by Stephenson, of which it now forms an integral part. However, with this superheater, the steam temperature attained rises and falls with the rate of evaporation and this varies greatly in locomotive service. When the engine is light working the steam temperature drops below a desirable value ; in such conditions the cut-offs tend to be early and the heat exchange between the steam and the cylinder walls is increased. On the other hand, high boiler ratings, particularly in undulating country, coincide with late cut-offs, with consequent reduction in the degree of heat exchange in the cylinders ; in flat country, heavy working does occur together with early cut-offs, but then piston speeds are high, which reduces the heat exchange. Under such circumstances very high superheat is, from the point of view of the thermal efficiency of the steam engine, less important ; also, the temperature of the cylinder walls tends to rise above a desirable value, and furthermore, the heat spent on excess superheating could be used with greater advantage to increase the evaporation. It follows that with medium and small boiler loads the degree of superheat should be increased without raising it in the higher load range.

It appears that this problem can be solved by adopting the principle of combined convection and radiation superheating for the locomotive boiler, the radiation section of the superheater being made from heat-resisting alloy steel and located in the combustion chamber or firebox. The customary smoketube superheater transmits heat predominantly by convection and hence shows a rising characteristic, i.e. the steam temperature increases with the load. As the falling characteristic of the radiation superheating surface tends to counteract the rising characteristic of the convection section of a combined convection and radiation superheater, the degree of superheat can be made largely independent of the boiler rating. Proposals have now also been made for such combined superheaters which are particularly adapted to the locomotive boiler. In fact, they may be fitted to existing boilers without much alteration. Such a combined superheater will not only produce high superheat also with light loads resulting in increased efficiency of the engine and reduced fuel consumption, but in addition the total amount of superheating surface, which at present is about 33 to 40 per cent of the evaporative heating surface, is very much diminished, owing to the fact that the radiant heat absorption per unit of surface is many times greater than that by convection. As a result, a larger evaporative heating surface can be accommodated, without increasing the outer dimensions and the weight of the boiler. Furthermore, the section of the superheater located in the radiation zone, by abstracting heat from the gases, reduces the temperature of the latter entering the boiler tubes. This in turn leads to a reduction in smokebox temperature, i.e. to improved boiler efficiency, without decrease in superheat. If, on the other hand, no lowering of the gas temperature at the firebox tube plate is contemplated, in other words, gas entering temperatures hitherto customary are desired, this is achieved by a higher firing rate, without a drop in boiler efficiency when compared with orthodox boiler arrangements. The combined result of both, the augmented evaporative heating surface and the position of radiant superheating surface between the grate and the firebox tube plate, is a marked increase in the steaming capacity of the boiler ; in consequence, a considerable increase in the indicated output and in the drawbar horsepower of the locmotive can be attained.

H. KAULLA

Canberra, Australia, January 24th.

* "The Railways and Coal." R. G. Jarvis, B.Sc. (Eng.), former Railway Executive, Southern Region. Joint Meeting, The Institute of Fuel and the Institution of Locomotive Engineers, May, 1952.

Short Notices

Machine Drawing and Design. Sixth edition. By W. Abbott, C.M.G., O.B.E., Ph.D., D.Sc., M.I.Mech.E. Glasgow : Blackie and Son, Ltd., 17, Stanhope Street. Price 15s.—This textbook has now been largely rewritten. It is intended to provide an intermediate course for students of mechanical engineering who are following university and technical college courses or are preparing for the examinations of the engineering institutions. The book opens with a section on machine drawing dealing with the principles of projection. Following sections deal with the design and drawing of fastenings, shafts and shaft fittings, bearings, gearing, valves, and engine details. The factors influencing design are then discussed, followed by notes on toleranced dimensions, toleranced working drawings, and some exercises in machine drawing and design to supplement those given in other sections of the book.

Books Received

The Electrical Year Book, 1955. Manchester : Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 3s.

Mechanical World Year Book, 1955. Manchester : Emmott and Co., Ltd., 31, King Street West, Manchester, 3. Price 3s. 6d.

Hydraulic Operation and Control of Machines. By Ian McNeill. London : Thames and Hudson, Ltd., 244, High Holborn, W.C.1. Price 35s.

World Railways, 1954–55. Third edition. Edited and compiled by Henry Sampson. London : World Railways, Ltd., 25, Gilbert Street, W.1. Price 84s.

Modern Physics for the Engineer By Louis N. Ridenour. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 53s. 6d.

Practical Lessons in Metal Turning and Screw Cutting. Revised edition. By Percival Marshall. London : Percival Marshall and Co., Ltd., 19 and 20, Noel Street, W.1. Price 6s.

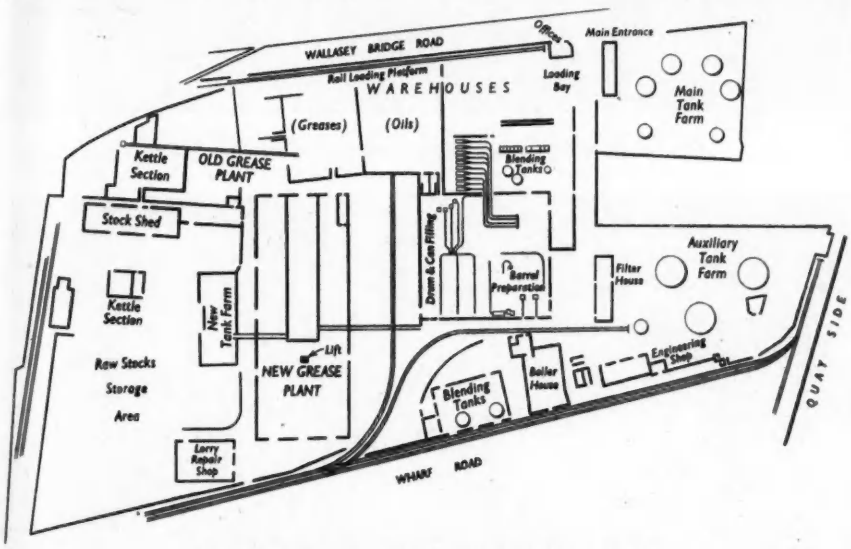
Plastics Engineering Handbook. Published by the Society of the Plastics Industry, Inc., 67, West 44th Street, New York, U.S.A. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 120s.

Radio and Television Engineers' Reference Book. Thirteenth edition. General editor, E. Molloy. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 70s.

Grease and Lubricants Plant

At the beginning of the century the Vacuum Oil Company, Ltd., established a centre in Birkenhead for the distribution and storage of lubricants. In the years that followed new plant was erected, most of which was destroyed during the second world war, and since then production has been carried on in temporary and partially reconstructed buildings. These have been largely rebuilt and the new grease plant was in full operation by June, 1954, producing between 1500 tons to 2000 tons of finished products per week.

IN June of last year the new grease plant of the Vacuum Oil Company, Ltd., came into full production and so fully re-established the grease and lubricant manufacturing activities of the company's Birkenhead works. These have had a chequered history, beginning in 1901, with the installation of storage tanks and followed nine years later by the building of oil blending tanks and a grease plant. It eventually became one of the largest production units in Europe, but was destroyed by enemy action in 1941. Since then production has been maintained by partially reconstructed and temporary plant until the reconstruction, begun in 1951, was completed. Our line drawing gives the outline arrangement of the Birkenhead works which are on the quayside at West Float, Birkenhead Docks, and which we were able to visit recently at the invitation of the company.



Site plan of the grease and lubricants plant at Birkenhead

The oil blending and compounding plant is capable of producing up to 2000 tons of finished products per week, depending upon the number and variety of grades required. Oils which are the basic stock, are brought to the site in bulk by means of coastal tankers, mainly from the company's Coryton refinery, and discharged by pipeline to the tank farm. From the storage tanks, some of which are insulated and steam heated, the oil stock is transferred through steam jacketed pipelines by remote control pumps to the blending tanks, where various fats and chemical additives are added in carefully measured quantities. About 80 per cent of the tonnage produced consists of some ninety-nine grades of lubricating oils and after blending these grades are stored in a warehouse tank having ninety-nine compartments and a total capacity of 2000 tons.

From the barrel preparation department where they are cleaned with a detergent, tested and dried, the barrels are moved by fixed roller and moving slat conveyors to the spray painting booths and then forward, again by conveyor, to the filling bay. Here the marked barrels are directed to the correct filling line and are filled at the rate of one per minute with a specific grade of lubricant from the warehouse storage tank. The filling arrangements include an automatic cut-off device operated by a mercury switch. From each filling booth the barrels are directed to two conveyor lines by means of a switch section in the conveyor system. A specially adapted fork lift truck removes the barrels, four at a time, and delivers them to storage or to rail or road transport systems, while arrangements exist for the direct loading of bulk road tankers. Another department is allocated for the filling of other packages ranging from one pint to four gallon drums. Several hundred other grades of lubricants are manufactured but these are in comparatively small quantities and are dealt with separately and stored for shipment as required.

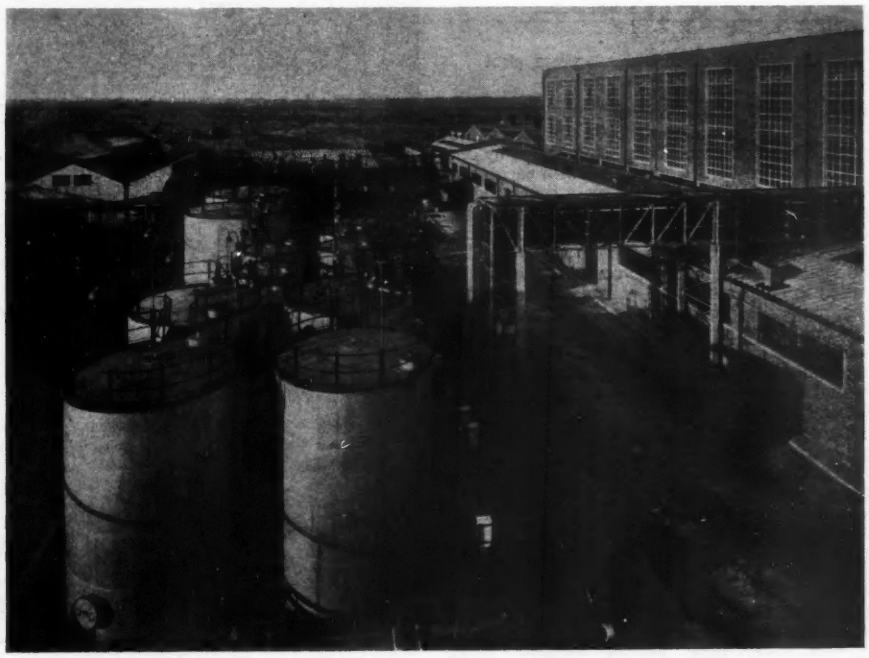
Description of Grease Plant

The existing warehouses and the presence of excellent road and rail facilities determined the position of the site for the new grease plant. Before building could commence it was necessary to drive some 300in by 17in reinforced concrete piles to carry the raft foundation because of the low load bearing characteristics of the ground. Before preparing the basic design of the new plant, a survey of existing grease plants was carried out and the final design and equipment incorporates the advances made in grease technology since the earlier plant was destroyed. The main contractor was Head, Wrightson Processes, Ltd., the civil contractors were Sir Alfred McAlpine and Son, Ltd., and A. Monk and Co., Ltd., and the plant is designed to produce about 250 grades of lubricating greases, while provision has been made for a 50 per cent increase in capacity.

The main building, of steel frame and brick panel construction, is about 363ft long, and 150ft wide, with three 50ft spans and consists of a three-storey manufacturing and packaging block with two single-storey wings for the storage of empty packages and raw stocks. The plant including the tank farm and oil heater covers an area of 68,989 square feet. Portal construction was adopted for the single-storey and centre top-storey parts of the building, which have 16in cavity walls and asbestos sheet roofing. Concrete slab construction was adopted for the ground floor while the first and second floors are of reinforced concrete *in situ* and all floors have a Steelcrete finish and are covered with non-slip monolithic flooring. The adoption of portal frames has made available greater working space and as a safeguard against fire all major building supports are encased in fire-resisting concrete and there is a 6in ring fire main. Fluorescent lighting has been adopted throughout and washing facilities are provided on each floor.

Our flow diagram generally indicates the main stages in the production of greases and that the process is "vertical." Greases can be broadly described as soap-thickened lubricating oils and the finished product, of which, as already mentioned, there are some 250 grades, vary in consistency from mobile fluids to hard solids. Briefly the process consists of first manufacturing a soap, made by boiling together fat or fatty acid with an alkali such as lime, caustic soda or some other metallic base, which is later dispersed in lubricating oil. The first process or saponification takes place in a "contactor" vessel and the second in a "kettle" in which the grease is manufactured.

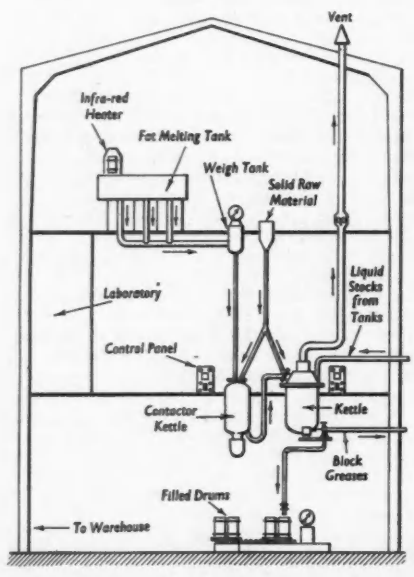
Raw stocks and mineral oils are stored in a tank farm which can be seen in our illustration below together with part of the main buildings. There are thirteen tanks ranging from 1000 barrels capacity to 150 barrels capacity. Packaged raw



Pipe bridge and the tank farms for liquid stocks for grease plant, part of which can be seen to the right

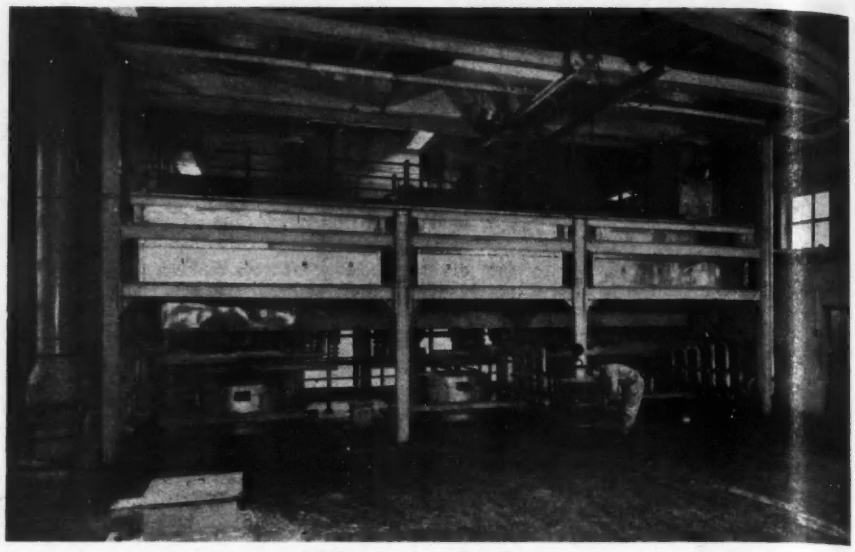
stocks such as fats and alkalis are delivered and stored in the ground floor warehouse from where they are transferred, by means of fork lift trucks and a 6-ton capacity lift, to the top floor. The whole of this floor is used for melting, weighing and dispensing of raw stocks for feeding the contactors and kettles. Solid stocks and powders are emptied into portable hoppers and weighed, after which the hoppers are transferred to chutes, through which the stocks are fed to the manufacturing vessels, and which are arranged so that none of the powdered stocks can escape to pollute the atmosphere. Those stocks which require to be melted are placed on hot grids over eleven steam heated dump tanks and are freed from their containers by means of a portable infra-red ray heating muffle. These tanks and the heating muffle can be seen in our photograph which shows part of the top floor. From the tanks the liquid fats pass to electrically heated scale tanks where the quantities are accurately weighed before delivery to the contactor.

The first floor is the main operating and manufacturing centre and here are located the contactors, kettles, laboratory, control panel and pilot plant. There are four contactor heaters, manufactured by the Stratford Engineering Corporation, U.S.A., three being of 6000 lb and one of 3000 lb capacity, and eight manufacturing kettles supplied by W. J. Fraser and Co., Ltd. These units include four of 15,000 lb,



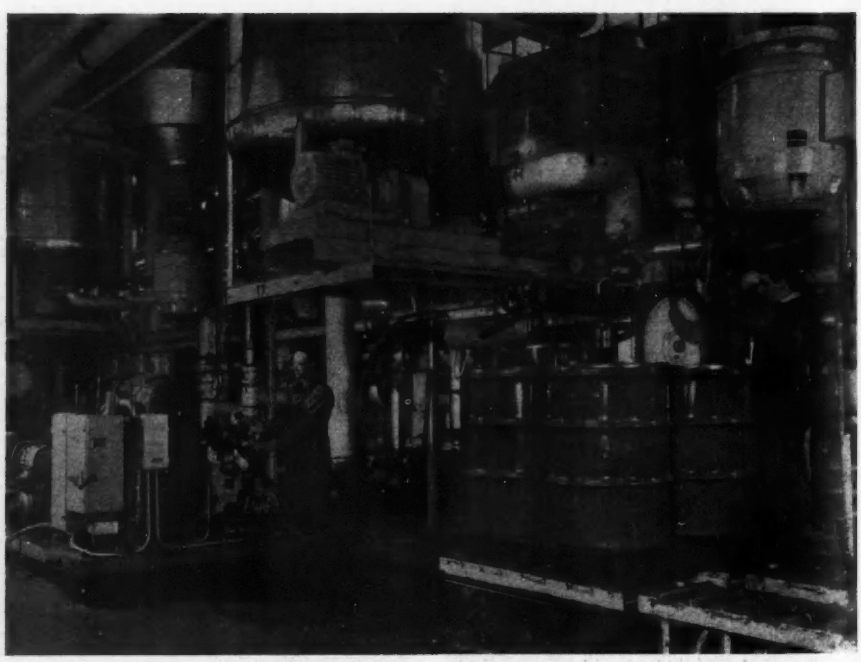
Flow diagram of Birkenhead grease plant

three of 8000 lb and one of 2000 lb capacity. Two 15,000 lb and two 8000 lb kettles are steam heated, the remainder being heated by oil. There are two kettles associated with each contactor and our illustration gives a general view of the manufacturing vessels. The design of the contactors, which are heated to about 550 deg. Fah. by hot oil, provides for the rapid circulation and dispersion of the contents which are raised in temperature and saponification begins, the process being completed in about twenty minutes. Heating of the contactors is by oil which is circulated by Hayward Tyler pumps through internal and external jackets and is heated to a temperature of 600 deg. Fah. in a vertical oil heater, manufactured by Head, Wrightson Processes, Ltd. The heating system contains 4500 gallons of oil and the heater, which has a capacity of 10,000,000 B.Th.U.s per hour, is automatically controlled and incorporates protective devices. It is fully instrumented with duplicate relays on the first floor of the plant. The circulation and heating of the contents of the contactor is effected by a high-speed impeller, fitted in the bottom of the vessel and driven by a 60 h.p. variable speed electric motor, which moves the contents over three heating surfaces. The contactors have steam connections for cleaning purposes and generate enough internal pressure



One end of top floor showing the fat tanks and infra-red ray muffle

First floor of plant showing controls, piping systems, kettles and contactors



Ground floor of plant showing the lower parts of contactors and kettles, a filling point and, to the left, a Cornell homogeniser

to effect the discharge of the contents to the kettles.

The kettles have machined internal surfaces and the materials are mixed by contra-rotating paddles fitted with scrapers to assist heat exchange and prevent local heating. All the vessels have control panels which ensure that the correct temperature and process time are maintained, while automatic shut-off meters are pre-set to control the quantity of oil supplied from the tank farm. To the soap concentration, discharged to the kettle from the contactor, there is added the mineral oil and other raw materials to give the grade of grease required and, dependent upon this, the final stages of manufacture take between one and five hours. Ventilating systems ensure that no fumes escape during manufacture.

In the laboratory a careful check is maintained upon the quality of the greases by penetrometer and other methods. In an adjoining compartment is a small pilot plant, supplied by the Stratford Engineering Corporation, which is a miniature manufacturing unit having a 100 lb capacity contactor and a 400 lb capacity kettle and is used for development work.

After laboratory approval the finished grease is pumped through a steam jacketed line and a filter by Stothert and Pitt rotary displacement pumps to a drum filling point, on the ground floor, where four drums are placed on a scale and filled one at a time. The filled packages are removed by fork lift truck to a cooling area before they are finally sealed and forwarded to the loading bay. Our illustration shows a filling point and also a Cornell grease homogeniser which is used for the mixing of certain grades of grease additional to the mixing in the kettle. The machine makes use of centrifugal action and operates under vacuum which not only breaks down the structure of the grease but serves as a de-aeration unit. Block greases are dealt with in a section of the single storey area and are delivered from the first floor into trays on a conveyor on the ground floor. Over the conveyor there is a fume extractor, the length of the extractor and the speed of the conveyor being such that sufficient time is allowed for the grease in the trays to cool to a temperature at which a skin can be formed. Some of these greases having a high melting point and soap content are extruded from a small press to the correct shape to suit locomotive driving journals. Another machine cuts slabs of grease into the correct size of block for paper mills.

The 440V, three phase, 50 c/s electrical supply is taken from the grid through a substation on the ground floor with a capacity of 500kVA. An artesian well within the works area supplies the necessary cooling water and for heating the manufacturing vessels steam is provided at 120 lb per square inch, the pass out steam being used for general low pressure heating.

Progress of the Metropolitan Water Board's New Works in 1954

THE progress made by the Metropolitan Water Board during the past year on its programme of new works is noted hereunder. One of the principal works which has been under construction for a number of years is the new filtration works at Ashford Common, which was designed to provide a supply of 90 m.g.d. of filtered water. Construction of the thirty-two filters at Ashford Common was completed in 1954 and temporary pumping arrangements were installed and filtered water was delivered, as required, to Kempton Park for repumping. Work was started on the construction of the micro-strainer house which is to house twenty-four strainers, each 10ft in diameter and of 10ft effective length, and nineteen strainers were delivered by Glenfield and Kennedy, Ltd. This installation will form the largest battery of such strainers yet constructed. The two contact and balancing tanks, each of 5·8 m.g. capacity, and the two low-lift pump houses, which will pump water into the contact and balancing tanks, were completed. A low-lift pump installation is illustrated herewith.

Work continued on the interior of the main pumping station building and also on the erection of the machinery. The main high-lift and low-lift pumping machinery and one of the gas turbine generating sets (mentioned in our article "Gas Turbines in 1954," January 14th issue) were substantially completed and the diesel generating sets were installed. A considerable amount of work remains to be done on the smaller ancillary installations and control gear, as well as acoustic treatment and finishing on the interior of the building. Site erection of the sand handling bridge, which will operate in conjunction with a central sandwashing plant, was completed. Manufacture was commenced of the plant designed to carry out *in situ* the washing of filter bed sand. This plant was described in our last year's review. The main contractor at Ashford Common is John Mowlem and Co., Ltd. The total cost of the Ashford Common filtration plant is estimated at about £4,500,000; construction was started in 1947 and is due to be completed next year.

Chingford South Pumping Station.—Up to the present the new William Girling reservoir in the Lee Valley has been filled by a connection from the older King George's reservoir. The existing pumping station is not, however, adequate for filling both reservoirs and a new station was proposed for filling the new reservoir, both to increase the pumping capacity and provide more suitable pumps. In March work was commenced by Caffin and Co., Ltd., on the construction of the new raw water pumping station at Lee Valley Road, where water abstracted from the River Lee will normally be pumped into the William Girling reservoir. The new pumping station will be of reinforced concrete construction and the pumps to be installed will be electrically driven, vertical-spindle propeller units with an installed capacity of 150 m.g.d. Arrangements will also be made for pumping water into the King George's reservoir. The pumping station buildings were completed approximately to ground level by the end of the year.

Hampton.—In previous years reference was made to the remodelling of Hampton works, which has been carried out in stages over a long period owing to the necessity of maintaining the output of the works whilst reconstruction was in progress. In June, 1954, the pumping connections for the new raw water pumping station at Sunnyside were completed by J. L. Eve Construction Company, Ltd., and this virtually completed the reconstruction of the Hampton works as originally envisaged. Work was continued on the reconstruction of the slow sand filter beds by direct labour and this work will be continued for many years as only one filter bed can be taken out of service at a time.

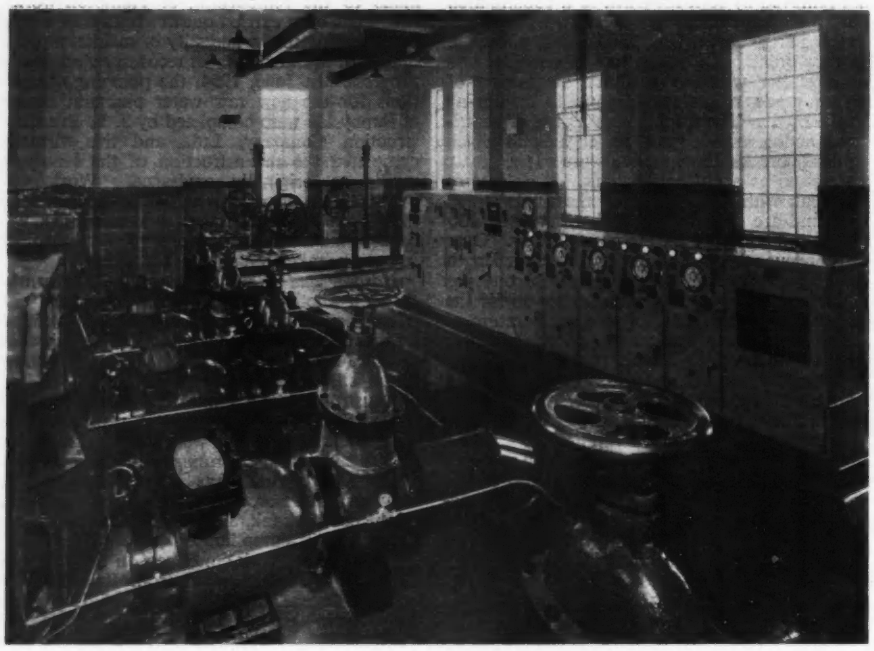
Hornsey and Stoke Newington.—At Hornsey the construction of a chemical treatment and balancing tank, low-lift pump house and chemical treatment building was completed and they were put into service on July 1st. The low-lift pump house is illustrated herewith.

Construction of a similar tank on a congested site at Stoke Newington was in progress. The outer walls in cofferdam were nearing completion and excavation of the dumpling was 75 per cent completed. Work was proceeding on the columns, sub-floor, centre division wall and roof of the contact tank, and also on the excavations to the low-lift pump house.

Knockholt.—Work continued on the laying of 3800 yards of 18in main from Knockholt to Berry's Green and 2500 yards of 12in main from Berry's Green to Biggin Hill, and was completed in November. These mains were laid from the existing 0·5 m.g. service reservoir at Knockholt to meet a considerably increased demand for water in these areas due to post-war development. In order to make full use of the water that is available from the Sundridge and Brasted well stations it is hoped to start early in the New Year on the second stage of the scheme, which includes for the laying of a 21in–24in main from Sundridge to Knockholt, joined by a 12in main from Brasted and the laying of a 12in main from Berry's Green to Farnborough.

In July work was commenced by John Howard and Co., Ltd., on the construction of a new service reservoir at Knockholt. When completed this reservoir will enable full advantage to be taken of the water available from the well stations south of Knockholt and will provide a margin of safety to meet the demands for water by the growing population, particularly during peak periods. The reservoir will have a capacity of over 5 m.g. and will be constructed with mass concrete buttress walls and a reinforced concrete roof. Bulk excavation work was substantially completed and about half the wall footings were excavated and concreted by the end of the year.

Low lift pumps at Ashford Common filtration works. The works will have a capacity of 90 m.g.d. and is the Board's largest scheme under construction



Low lift pumps installed to serve a chemical treatment and balancing tank at Hornsey

Lee Bridge.—The installation of ten rotary strainers, each 10ft in diameter and 10ft long, arranged in five reinforced concrete chambers, and the superstructure to the screening house, were completed. This plant has been installed to enable the station to maintain output with water of poor filterability, especially during algal infestations. It was illustrated in Plate 2 of our issue of January 7th.

Mains.—The fourth and last section of the 60in trunk main from Kempton Park to Cricklewood, including the connections within Cricklewood works, was completed by J. B. Edwards and Co. (Whyteleafe), Ltd., in July.

To meet the development, both of industry and housing in the Edmonton and Cheshunt areas the Board approved the laying of 3350 yards of 24in main from Caversham Avenue, Southgate, to Great Cambridge Road, Edmonton. Work was commenced in April and by the end of the year 2500 yards of the 24in main were laid.

In the last year's review the Board's proposals were described for the construction of a 102in raw water main in tunnel from the Thames to the Lee Valley. A contract was awarded to Balfour Beatty and Co., Ltd., for the construction of approximately 2900ft of shield driven tunnel, to be driven north-eastwards from an existing shaft adjacent to the Board's West reservoir at Stoke Newington. The tunnel will be lined mainly with precast concrete segments of a new design known as the "Wedge-block" design. Preparations were being made so that tunnel driving could be commenced early in the New Year. The design of this tunnel is of considerable interest to the civil engineer, and it has been mentioned on several occasions in these columns. In our issue of December 31st last, we printed an abstract from Dr. F. M. Lea's Unwin lecture, which included a description of the tests carried out to assess the loads in the lining of an experimental length of tunnel of similar design.

North-East London : Improvement of Supplies.—An area of about 26 square miles in North-East London is dependent for almost the whole of its supply on the repumping at Woodford of water delivered to that station from Lee Bridge and Ferry Lane works. This area is divided into two pressure zones which are supplied under the heads of High Beech reservoir of 2·15 m.g. capacity and Buckhurst Hill reservoir of 0·8 m.g. capacity. Much development has taken place in North-East London in recent years and in 1953 the Board approved proposals estimated to cost £450,850 to improve the supply to this area and to meet expected future demands. The scheme includes extension of Woodford pumping station and installation of additional machinery, a new service reservoir at Chigwell, trunk and interconnecting mains and a booster station. The first stage of the scheme was commenced last year ; it includes the construction of a small booster station on a site adjacent to the proposed service reservoir, and the laying of the necessary connections, so that adequate supplies and pressures could be maintained locally where the greatest deficiencies in supply are at present experienced.

Other Works.—During the year under review work was continued on the remodelling schemes at Chingford Mill, Hammersmith, Hoe Lane, Honor Oak and Stoke Newington pumping stations. Boiler shells were converted into high-pressure contact tanks at a number of the Board's well stations. In our issue of June 4th last, we briefly noted another interesting aspect of the Board's work, namely, the use of tractors and other plant for mechanising the cleaning of slow sand filter beds. A scheme of mechanisation was to be introduced to cover all the Board's slow sand filter beds, it was noted.

Technical Report

Flexure Devices : Pivots, Movements, Suspensions. By P. J. Geary. 1954 : Research Report M.18. The British Scientific Instrument Research Association, "Sira," Southill, Elmstead Woods, Kent. Price 10s. 6d. post free.—The present booklet is the first of a series of bibliographical surveys on instrument parts, and covers the use in instruments of flexible connections in bending. It does not include strips in torsion (it is intended to deal with these in a separate publication) or bimetallic strips. The survey has been grouped under six headings : flexure pivots, parallel movements, twin strip mechanisms, buckling strip devices, rolling suspensions, and the sine spring. Under each of these headings are given illustrations of the principal designs with brief notes on their mode of action, application and history. This is followed by abstracts of twenty-eight "principal" texts, and a list of 111 "secondary" references, published since 1900. It is pointed out that the distinction according to importance is bound to some extent to be an arbitrary one, but it is felt that such preliminary classification will be of help to the general reader. A third list contains seventeen supplementary references to papers which at the time of going to press had either not been located or had not been examined. With the exception of some of the papers in this last list, full bibliographical details and subject references are given for each publication, and there is a separate name index. Emphasis is laid on flexure supports, as devices which for many applications have advantages over such elements as pivots and knife edges. They are robust, friction-less, free from backlash or wear, almost free from hysteresis, and do not require lubrication. In most forms they are unaffected by dust or dirt ; restoring moments are small and often fulfil a useful function ; in other cases the stiffness can be reduced to zero or made negative by changing its geometry or the pre-loading of the joint. For all these reasons, flexure devices deserve to be more widely known than they appear to be at the present time. This concise and well-arranged bibliography should be of much value not only to instrument engineers, but also to designers in many other fields, and future volumes in this series will be looked forward to with great interest.

Economic Selection of Cooling Towers for Generating Stations*

By GEOFFREY F. KENNEDY, M.A., and P. H. MARGEN B.Sc. (Eng.)

This paper describes the construction of charts showing the economic duty conditions of natural and mechanical draught cooling towers for generating stations in the British climate. The charts are drawn in terms of two factors, namely (a) *the annual station load factor, and* (b) *the full-load turbine heat rejection per square foot of net exhaust area. Typical seasonal temperature and load cycles are assumed.*

BRITISH generating plant to be constructed during the next few years consists largely of three standard types of plant, i.e. 60MW, 120MW and 200MW units. Once the decision has been made as to which of these three standards should be used on a given site, nearly all plant particulars are automatically fixed. The only major plant item which, so far, has escaped this process of standardisation is the cooling tower, and this continues to be built in a great variety of sizes and forms. It is therefore important to examine in detail by what methods economic cooling towers can be selected.

In stations relying entirely on cooling towers, the circulating water absorbs heat in the condenser, and is thus raised from θ_1 deg. to θ_2 deg.

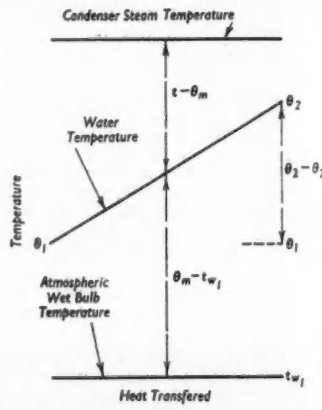


Fig. 1—Heat transfer diagram for station relying wholly on cooling towers

Fah. It then passes through the cooling tower, where it is recooled to θ_1 deg.

In Fig. 1 we show the temperatures on a heat transfer diagram. The bottom line represents the atmospheric wet bulb temperature—which is the coldest temperature to which water can be cooled by contact with the atmosphere—the middle line represents the water temperature, and the top line the steam temperature in the condenser. If very large cooling towers, condensers and circulating water pumps are installed, then the vertical spacing between these three lines becomes small, and so the condenser steam temperature is low. As a result the turbo-generator has a high electrical output per unit heat reject, i.e. is thermally efficient. On the other hand, this desirable feature is obtained only at the cost of relatively large and, therefore, expensive cooling towers, condensers and circulating water pumps, and so there is an economic compromise at given spacings between the three lines. To show what these economic spacings are for various conditions, we reproduce graphs relating the economic mean cooling tower temperature difference, $(\theta_m - t_{w1})$, the economic mean condenser temperature difference, $(t - \theta_m)$,

* Institution of Electrical Engineers, Supply Section. London, January 5th.

and the economic water temperature range $(\theta_2-\theta_1)$ to various conditions.

Conditions Influencing Cooling Tower Selection

There are three main conditions which influence the economic values of these three temperature terms, namely :

(*a*) The climate ;
(*b*) The station load programme, and
(*c*) The turbo-generator performance/vacuum characteristic.

As far as British stations relying solely on cooling towers are concerned, the climate is practically the same at all points of the British Isles and may be represented by the effective mean seasonal temperatures shown on Table I :

Table I—*Assumed Mean Atmospheric Temperatures.*

Season	Temperature	
	Wet bulb	Dry bulb
	Deg. Fah.	Deg. Fah.
Winter	41	43
Intermediate	49	52
Summer	57	61

The second condition, namely, the station load programme, does vary to some extent for different stations, but it is found that the programmes for most stations operating on a given annual load factor are similar and can be represented by simplified loading diagrams. Therefore, the second condition can be represented by the annual load factor alone.

The third condition, namely, the turbine performance/vacuum characteristic, is best represented in the manner shown on Fig. 2, where the incremental generator output (i.e. the performance gain per degree reduction in condenser steam temperature) is plotted against the condenser steam temperature. The curves have been calculated for various values of the " turbine exhaust heat loading," q_e, i.e. the rate of heat rejection per square foot of net turbine exhaust area. The greater the value of the exhaust heat loading, the greater is the turbine leaving loss and hence the smaller is the performance gain obtainable by reducing the condenser steam temperature. The curves on Fig. 3 show this fact very clearly.

Calculated Economic Duty Conditions

In Fig. 3(*a*) we show the results of our calculations for natural draught cooling towers, i.e. the towers with great reinforced concrete chimneys which form such a distinctive feature of most British power stations. The numerals on the curves plotted on that diagram represent the mean cooling tower temperature difference. The abscissa is the station load factor, and the ordinate is the turbine exhaust heat loading.†

The diagram shows clearly that turbines having high exhaust heat loadings should be associated with relatively high circulating water temperatures. In other words, when the turbine exhaust heat loading is high, the incremental generator output is so low that it is not worth while spending a large capital sum on the cooling towers in order to obtain low water temperatures. This is a very important conclusion, for as turbine ratings increase the areas of exhaust cannot increase in proportion to the quantity of heat rejected. Hence there is at present a very pronounced trend towards higher turbine exhaust heat loadings, and this must be accompanied by cooling tower specifications calling for higher water temperatures, if the best overall economy is to be obtained.

Fig. 3(*b*) provides similar information for mechanical draught cooling towers, i.e. those compact towers in which the conspicuous concrete chimneys are replaced by induced or forced draught fans. The main point of interest here is that the economic water temperatures are lower than for natural draught towers. Hence, where it is desired to make a full economic comparison between the two kinds of tower, different performance specifications should be framed for the two kinds. This is a point to which insufficient attention has been given in the past.

The continuous lines on the next diagram, Fig. 4, show the economic circulating water temperature range. The values are, for example, 18 deg. Fah. for an exhaust heat loading of 1500 B.Th.U. per second per square foot, whereas in the past values as low as 12 deg. were often used for similar conditions, because cooling tower performance relations had not, at that time, been properly understood. The tendency to employ larger water quantities and also physically larger towers than those giving the most economic results has increased the tower is supreme. On the continent of Europe both kinds are in wide use, and so, on a world basis, honours are about even at present.

The results of our calculations for the British climate based on cost data available about eighteen months ago are represented on Fig. 5. For turbine exhaust heat loadings above the shaded line natural draught towers are economic, and for those below the shaded lines, mechanical draught towers. In future, most turbo-generators built for British stations will lie in the top half of the chart, and will thus favour the adoption of natural draught towers. In some instances, this may achieve quite appreciable savings when compared with the adoption of mechanical draught ; for instance, an amount of more than 15 per cent of the cooling tower capital charges when the turbine exhaust heat loading is 2000 B.Th.U. per second per square foot.

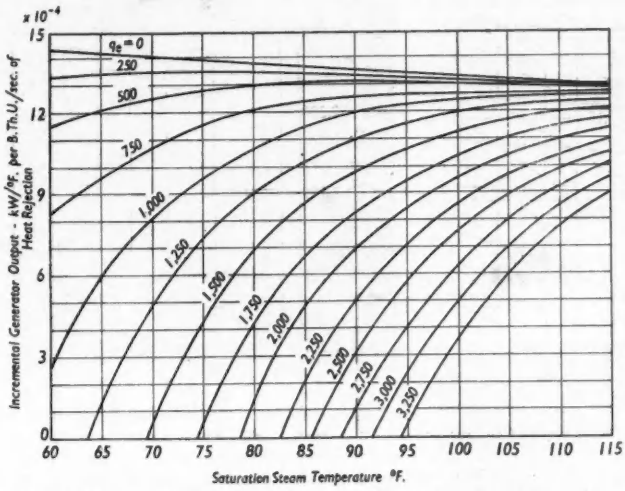
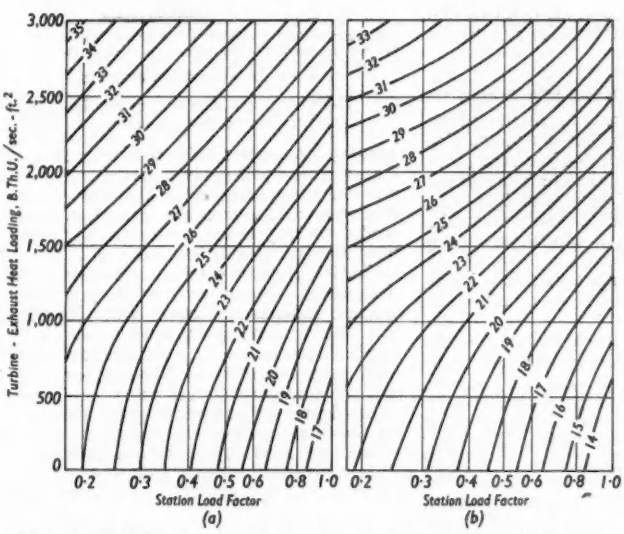


Fig. 2—Incremental generator output per degree Fahrenheit reduction in condenser steam temperature (based on $\eta_t=0\cdot7$)



The curves show the temperature difference (θ_m-t_{w1}) to be specified at the reference conditions of atmospheric temperatures : wet bulb=49 deg. Fah.; dry bulb=52 deg. Fah.
(*a*) Natural draught. (*b*) Mechanical draught.

Fig. 3—Economic mean temperature difference of cooling towers

It is interesting to examine why the turbine exhaust heat loading should have so large an influence on the economic comparison. In effect, the natural draught chimney may be regarded as a heat engine, which develops useful air power in proportion to the quantity of heat supplied to it and the height of the chimney. The heat is a waste product, so that the chimney is economic if the power developed from this free heat is sufficient to pay for the capital charges. Fig. 3(*a*) has shown that an increase in the turbine exhaust heat loading produces an increase in the economic water temperatures, and hence a reduction in the economic ground area of the chimney. In other words, the chimney can still develop the same air power, but costs less to construct and is therefore more economic.

Fig. 6 shows that the dividing lines between the economic spheres of application of natural and mechanical draught towers occurs at higher turbine exhaust heat loadings in hot climates than it does in cold climates. The reason for this is that the power which a cooling tower chimney can develop from a given quantity of heat falls with increasing climatic temperatures. The effect of climate on the economic comparison is one of the reasons why mechanical draught towers find favour in the U.S.A., where the mean atmospheric temperatures are much higher than in Britain. It also shows why mechanical draught towers are economic on certain British sites where the towers have to operate mainly in the warm summer months, since the local rivers have sufficiently large discharges in the winter to absorb most of the heat without the assistance of cooling towers.

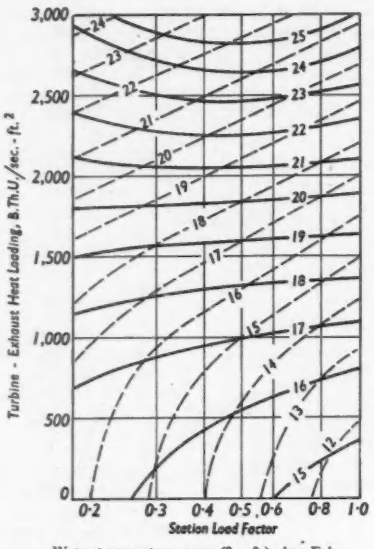
Having described the results of our calculations for this economic comparison, we have to make certain reservations. Site conditions and the prevailing rate of financial interest do affect the comparison to a certain extent. Also, the design of one or other of these types is modified periodically, for example, by the introduction of a wooden system of supporting the cooling tower laths in natural draught towers which is now becoming popular and is reducing costs by capitalised costs by amounts reaching £200,000 in some stations. The position can, however, often be rectified by operating fewer pumps and by installing extra generating plant without adding to the cooling tower capacity of the installation. It is worth mentioning that the tendency towards building excessively large towers for a given heat quantity arose partly from the fear of water carry over. This fear has now been met by the development of an eliminator by the British Electricity Authority.

Natural versus Mechanical Draught Cooling Towers

We next come to a question which has been debated vigorously on several continents, namely, the relative merits of natural and mechanical draught towers for generating stations. In Britain it is the natural draught tower which has held the field almost exclusively for many years, whilst in the U.S.A. the mechanical draught

† Figs. 3(*a*) and 3(*b*) give the tower performance at the following atmospheric reference temperatures :—Wet bulb, 49 deg. Fah.; dry bulb, 52 deg. Fah.

appreciable amounts. Such changes in conditions and cost factors do affect the precise position of the dividing lines between the economic spheres of application of the alternative types, and so it will be desirable to re-examine the problem from time to time. What does emerge quite clearly from our charts is that the trend



——— Water temperature range ($\theta_2 - \theta_1$), deg. Fah.
- - - - - - - Algebraic mean temperature difference across condenser ($t - \theta_m$), deg. Fah.
The curves are calculated for natural-draught cooling towers, but apply to mechanical-draught towers within ±1 deg. Fah.

Fig. 4—Economic water temperature range and condenser temperature difference

towards larger turbo-generators favours natural draught designs, and that hot climates favour mechanical draught.

Combined River and Cooling Tower Schemes

The last problem we want to discuss relates to stations which employ both rivers and cooling towers for rejecting the heat of condensation. What many people would regard little more than a stream under average flow conditions can, when integrated into a cooling tower scheme, be instrumental in achieving a capitalised saving of about £200,000.

[In the paper, calculations are given for a larger river and the estimated capitalised saving is £550,000.]

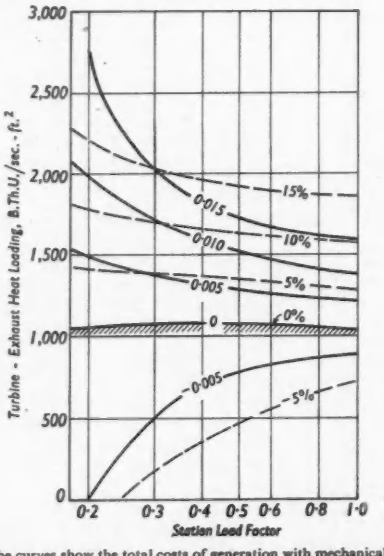
This estimated saving arises as follows :—

(*a*) Since the river can absorb 76 per cent of the annual heat rejection of a 240MW station, smaller cooling towers are economic, and hence the capital cost of the towers is reduced.

(*b*) Since the river water is colder than the discharge from the cooling towers, the combined scheme achieves a slight improvement in the average station vacuum.

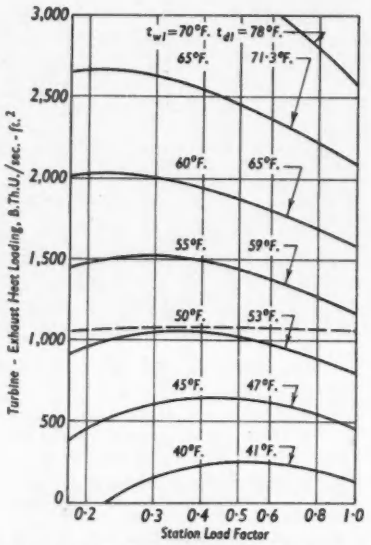
(*c*) Since the river water need not be pumped against the static head of the cooling towers, there is a reduction in the pumping power consumptions.

The third of these points is illustrated by Fig. 7, which shows a schematic representation of a circuit for a river and cooling tower stations. In this circuit the main water



The curves show the total costs of generation with mechanical-draught towers less the total costs of generation with natural-draught towers.
——— £ per annum per B.Th.U./sec. of full-load heat rejection.
- - - - - - - Percentage of economic capital charges on natural-draught towers.

Fig. 5—Economic comparison of natural and mechanical-draught towers for British stations



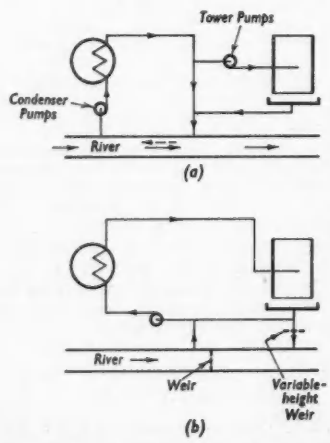
The curves show the conditions under which both towers give the same overall cost of generation, natural-draught towers being economic above the curve.
- - - - - British conditions (from Fig. 5).

Fig. 6—Influence of climate on relative merits of natural and mechanical-draught towers

quantity passes through the condenser pumps and the separate cooling tower pumps are brought into operation only when the river discharge becomes so low that the cooling towers are needed to keep the downstream river temperatures at an acceptably low value.

Fig. 7(*b*) shows a circuit suitable for a smaller river where it is not worth while providing two separate batteries of pumps. With this arrangement the pumping power consumption is practically the same as with a straight cooling tower scheme, but the economy in cooling tower capital cost and station vacuum remains.

The figures derived in the paper indicate that the use of rivers in correctly designed combined schemes can have very large financial advantages. The main obstacle to the wider use of rivers at the present time appears to be the absence of a clear policy to govern the permissible amount of heat rejection to rivers. We believe that an investigation would indicate that most rivers could absorb heat without significant disturbance to public and private interests, provided the river temperature rise or the actual temperature attained was kept below certain limits. Such an investigation might save the nation many million pounds. The latest annual report and accounts of the British Electricity Authority suggests that some investigations have started on this subject and it would be most interesting to hear about the extent of those investigations and their findings.



(*a*) Circuit with "shunt" across towers ; flow direction reverses during very low river discharges.
(*b*) Simple series circuit : modified arrangements without weirs are possible.

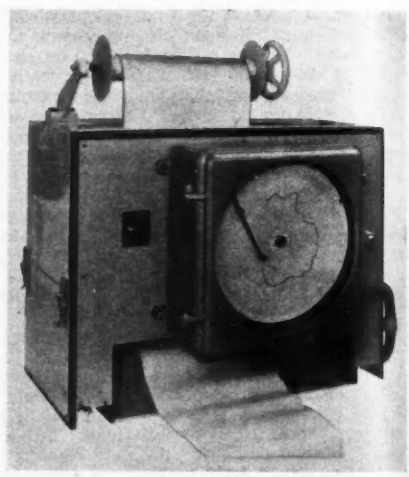
Fig. 7—Cooling circuits for combined river and tower scheme

Conclusions

We have tried to outline to-night some of the lessons which we ourselves have learned in our investigations into the technique of cooling tower selection, and particularly those lessons which might assist the designers of British stations. We should like to emphasise in particular that in the past cooling towers and circulating water quantities tended to be too large, and that still smaller towers and water quantities per unit of heat rejected will become economic with the advent of larger turbine ratings. Natural draught cooling towers tend to be economic for nearly all British stations relying on cooling towers only, though mechanical draught towers have a useful field of application in stations where they are required to operate mainly in the warm summer months. Hotter climates are more favourable to mechanical draught. Finally, we wish to emphasise the need for facing up to the very important problem of heat rejection to British rivers.

Measuring Instrument for Sheet Material

Some years ago the Baldwin Instrument Company, Ltd., Brooklands Works, Dartford, Kent, introduced the "Automat" instrument for the continuous non-contact measurement of weight of such sheet materials as paper, plastics, rubber, &c., during the course of manufacture on a machine. This instrument does not, however, give information on the variation in weight across the width of a sheet and for this purpose what is termed an automatic transverse profile apparatus has now been developed. On



Apparatus for measuring the variation in weight across the width of sheet material

the chart of the new instrument the weight at which the sheet being manufactured should be running is shown, together with the actual deviation from that set weight, the information being taken from a sample taken across the web. With this information a machine operator can effect the necessary adjustments to his machine when making high-quality, low-tolerance products. The makers of the instrument point out that in paper-making and coating work difficulty is often experienced in keeping reel hardness constant across the width of a

reel. Sometimes reels are found to be soft in the middle or at one or both edges; the information given by the transverse profile apparatus enables these factors to be quickly detected.

The "Automat" instrument is based upon the principle that when beta radiation, consisting of fast electrons from a radioactive source, is directed at a sheet of material, part of the radiation is reflected or scattered, another part is absorbed and, up to some limit set by the weight per unit area and the atomic number beyond which total absorption takes place, the remainder emerges on the other side of the sheet. The transmitted radiation can be arranged to fall on to a detector placed opposite the radioactive source, on the other side of the sheet, and the weight per unit area of the sheet determines how much of the incident radiation is transmitted to the detector. The ionisation current derived from the detector after appropriate amplification thus serves to indicate the weight per unit area of the sheet. The transverse profile unit, shown in the accompanying illustration, is in essence such an instrument.

In practice, the machine operator cuts off a strip of material about 12in wide across the end of each reel. This strip is then placed in the transverse profile apparatus and, on closing a switch, the strip of material is fed through automatically. The information thus obtained enables a complete record of the profile of the product, across the machine, to be kept.

Welding Shop Positioner and Tower Platform

A NEW positioning equipment for use when welding lightweight pipes, drums, &c., has been introduced by Donald Ross and Partners, Ltd., 1-3, Arlington Road, London, N.W.1. The positioning of light cylindrical work on the firm's normal roller positioners was not always satisfactory; loss of traction occurred when the rollers lost contact owing to the cylinders being out of round. This eccentricity caused uneven load distribution and tended to twist the workpiece out of the correct rotating position during the welding or cutting operation.

The new equipment is made in two sizes, with capacities of 1 ton and 2 tons, and it can be seen in the accompanying illustration. The equipment consists of two work supporting members, which can be spaced according to the length of the workpieces. Each member carries a rubber shod chain, which acts as a sling for the work. These chains, being flexible, shape themselves to the contour of the cylinder and act as a conveyor, enabling a large area of the cylinder to be contacted to give smooth rotation at all times. By this method loss of traction through single-point contact, as in the roller positioner, is eliminated and there is no corkscrewing of the cylinder from its correct position. The chains also support very thin shells without causing any indentation in them.

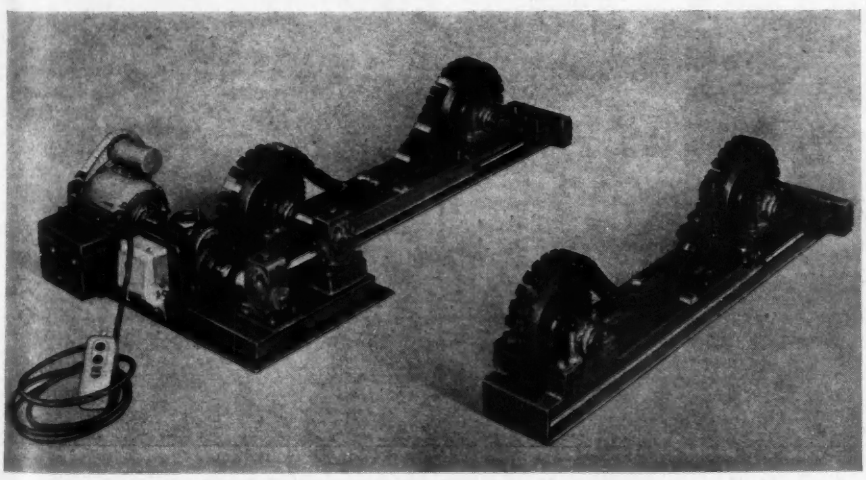
Adjustable platform for welding large diameter drums

A standard drive is fitted to one of the chains, with the second chain acting as an idler. The drive incorporates a 6–1 infinitely variable speed mechanism, giving a speed of 8in to 48in per minute at the chain.

By simple screw adjustment on one sprocket the loop on the chain is formed to suit the diameter of the loaded cylinder. A steel backing plate is interposed between the rubber shoes so that damaged shoes can be easily replaced.

Another new piece of welding shop equipment introduced by this firm is a mobile adjustable operator's platform for use when welding large-diameter drums set on rotating manipulators or for other classes of large work which normally call for the erection of temporary staging.

As can be seen from the second of our illustrations, the tower carrying the jib-supported platform is mounted on a triangulated angle-section base. The base is mounted on two wheels at the front and two castors at the rear to facilitate steering into the working position. When the tower has been positioned two jacking screws at the rear of the base are lowered to provide a stable support. The platform on the jib of the machine is 4ft 6in by 2ft 3in and is designed to take a safe working load of 4 cwt in any position. It can be adjusted to any height between 5ft 2in and 12ft 4in above floor level. Two 30in. stroke hydraulic jacks are pivoted to the lower part of the tower and the underside of the platform jib. These jacks are extended or retracted to raise or lower the platform, and they are supplied with pressure fluid by a hand-operated hydraulic pump at the rear of the base.



Welding positioner with rubber-shod chains for supporting and rotating light cylindrical workpieces

Flexible Plastic Ducting

A FORM of flexible ducting made from plastic material which has been in use on the Continent for some time is now being supplied under the trade name "Flexadux" by Wilkinson Rubber Linatex, Ltd., Camberley, Surrey. The ducting is made of polyvinyl chloride plasticised with tricresyl phosphate and relatively long lengths can be collapsed into a small space for transport or storage. This material, in addition to having a relatively high tensile strength, it is claimed, is rot-proof, does not support combustion, is age-resisting and can be used safely in temperatures varying from 25 deg. Cent. below zero to 60 deg. Cent. above. When damaged a duct can easily be repaired on siteby welding with an electrically heated hand tool.

The ducting is available in three types. The first incorporates a continuous helical steel stiffening wire, and is suitable for both positive

Flexible plastic ducting with continuous helical stiffening wire. A connecting clip is shown with the top half hinged back

and negative pressures of up to 20in w.g. It is made in seven diameters from 8in up to 32in, and in standard lengths of 13ft, although if required longer lengths can be supplied. The second type of ducting is fitted with steel stiffening rings in the form of hoops and is suitable only for a positive pressure of 20in w.g. This ducting is available in five diameters from 8in to 24in and in standard lengths of 13ft. The third, flat, form of ducting is intended for emergency use only and has no stiffening rings along its length. It withstands positive pressures only, of up to 20in w.g. This flat ducting is made in two diameters of 8in and 12in and it can be supplied in lengths of up to 150ft.

The steel coupling rings fitted at the ends of the sections of ducting and the stiffening rings are totally enclosed in plastic to prevent corrosion. The steel stiffening rings are arranged on the outside of the duct walls so as to provide an unobstructed flow passage through the bore.

In order to ensure an airtight connection between lengths of ducting the simple hinged clip to be seen in the accompanying illustration is used. The steel-ring-reinforced ends of the ducts are placed in one-half of the clip, and when the other half is swung over a firm connection is made by locking with an adjustable lever which is integral with the clip.

The recommended way of installing "Flexadux" is by suspending it from guide ropes and for this purpose hooks are provided at regular intervals on the ducts. These hooks have small thumb-screws by which the hooks are anchored to the guide ropes after the ducting has been extended.

Ventilated Squirrel-Cage Motors to N.E.M.A. Revised Standards

A NEW range of small, ventilated, squirrel-cage induction motors with outputs from ½ h.p. to 25 h.p. is being manufactured by the English Electric Company, Ltd., Stafford. They are known as Class "LE" motors and their dimensions comply with the revised standard of the United States National Electrical Manufacturers' Association (N.E.M.A.). Accordingly they should be suitable for manufacturers exporting machine tools to dollar areas and for users of American machine tools who will now be able to obtain the correct motor in Great Britain.

Comparison of Motor Frame Sizes

H.P.	Poles	Class "LE" motors, protected	British Standard dimensioned motors, Class "LY" totally enclosed	Old N.E.M.A sizes
½	8	A.182	B.203	204
¾	6	A.182	B.183	203
	8	A.184	B.204	224
1	4	A.182	B.183	203
	6	A.184	B.203	204
	8	A.213	B.204	225
1½	2	A.182	B.183	203
	4	A.184	B.203	204
	6	A.184	B.204	224
	8	A.213	—	254
2	2	A.184	B.203	204
	4	A.184	B.204	224
	6	A.213	B.204	225
	8	A.215	B.225	254
3	2	A.184	B.204	224
	4	A.213	B.204	225
	6	A.215	B.225	254
	8	A.254	B.254	284
5	2	A.213	B.204	225
	4	A.215	B.225	254
	6	A.254	B.254	284
	8	A.256	B.284	324
7½	2	A.215	B.225	254
	4	A.254	B.254	284
	6	A.256	B.284	324
	8	A.284	B.324	326
10	2	A.254	B.254	284
	4	A.256	B.284	324
	6	A.284	B.324	326
	8	A.286	B.326	364
15	2	A.256	B.284	324
	4	A.284	B.324	326
	6	—	B.326	364
20	2	A.284	B.324	326
	4	A.286	B.326	364
25	2	A.286	B.326	364

The accompanying table shows frame sizes of the new English Electric "LE" motors, motors complying with British Standard and motors made to the old N.E.M.A. requirements. If the first two digits of the frame sizes in each column of the table are divided by four the height, in inches, of the shaft centre is obtained: thus, an A.184 frame has a shaft centre height of 4½in. All motors in the new range can be supplied for operation at any standard frequency and voltage and the bearings are of metric sizes.

The machines comply with British Standard 168 : 1936, and with the requirements of the Factory Act and have the approval of the Canadian Standards Association.

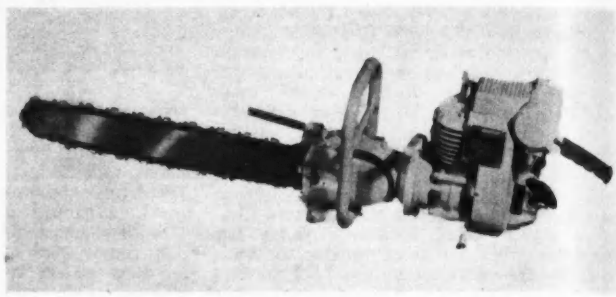
The four standard frame sizes are illustrated herewith. The motor end shields have wide flares to allow improved air flow and the vents are fully ventilated. The standard position of the terminal box is on the right-hand side of the motor when looking at the non-driving end. If the terminal box is required on the left-hand side, however, the change can be achieved by removing both end shields and the rotor, reversing the stator and reassembling. The box is normally supplied with the cable entry pointing downwards, but it can easily be turned for cable entry from right, above or left, without disturbing the motor internal leads.

Portable Chain Saw

WE reproduce on this page a photograph of a new design of petrol-engine-driven chain saw now being made by J. Clubley Armstrong Danarm, Ltd., Abford House, Wilton Road, London, S.W.1. It is known as the "Whipper" and supersedes the "Tornado" saw which has been made by the firm for a number of years.

This saw is much lighter and more compact than the previous design, although it is capable of all the same classes of work, such as tree felling, lopping and cross-cutting. When it is fitted with a 14in. guide blade the new saw weighs only 27 lb, compared with the 42 lb of previous models.

The air-cooled petrol engine has a chromium plated aluminium cylinder designed to give long trouble-free service and a re-wind pull starter is now fitted. Drive from the engine is transmitted through a gearbox and a centrifugal clutch, which is automatically disengaged when the engine is throttled back to a predetermined idling speed. The introduction of this centrifugal clutch has eliminated need for a clutch lever and drive of the chain saw is automatically engaged as the engine is accelerated by operation of the throttle lever. Now that the clutch lever has been dispensed with, cuts can be made with the operator holding the machine with one hand and supporting the work with the other hand or the machine can readily be changed from hand to hand. The gearbox and blade assembly can be rotated to any required angle relative to the engine for sawing horizontally or at an angle.



Petrol-engine-driven portable chain saw fitted with a 14in guide blade and having a chain speed of 20ft per second

An automatic oil pump in the engine provides a feed of lubricating oil to the chain through a visual oil metering device. The machine takes guide blades up to 30in and a "chipper" chain is supplied for sawing soft or average timber or a "Butterfly" chain for very hard timber.

Large Capacity Rear Dump Trucks

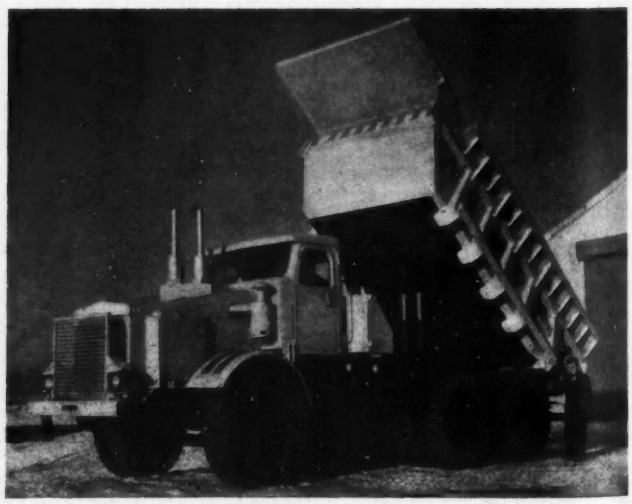
A FLEET of "Euclid" 20 cubic yards capacity rear dump trucks is being placed in service by George Wimpey and Co., Ltd., at the Maesgwyn opencast coal site in South Wales. These trucks, one of which can be seen in the illustration below, are stated to be the heaviest vehicles of their kind working in this country. Each truck is built to carry a payload of some 30 tons and has an unladen weight of over 30 tons.

The trucks have two 200 h.p. six-cylinder diesel engines mounted side by side and each engine drives one of the two rear axles through a separate three-speed gearbox and a torque converter. No clutch pedal or manual gear change is provided, the transmission being designed to permit the driver to change into any required gear under full power at any speed. The two double reduction rear axles operate independently of each other and are spring mounted about a central pivot. The steering is hydraulically assisted and air-operated brakes are fitted on the front and rear axles.

The 19ft long, 9ft 8in wide tipping body hinges on the rear of the frame and is actuated by two three-stage double-acting hydraulic cylinders controlled through a four-way valve for raising, lowering, holding and free movement. Constant delivery gear pumps, driven from each of the transmission systems, supply oil at 1500 lb per square inch to the hydraulic system of the truck.

The equipment made by the Euclid Road Machinery Company, of the United States, is handled in this country by John Blackwood Hodge and Co., Ltd., 11, Berkeley Street, London, W.1.

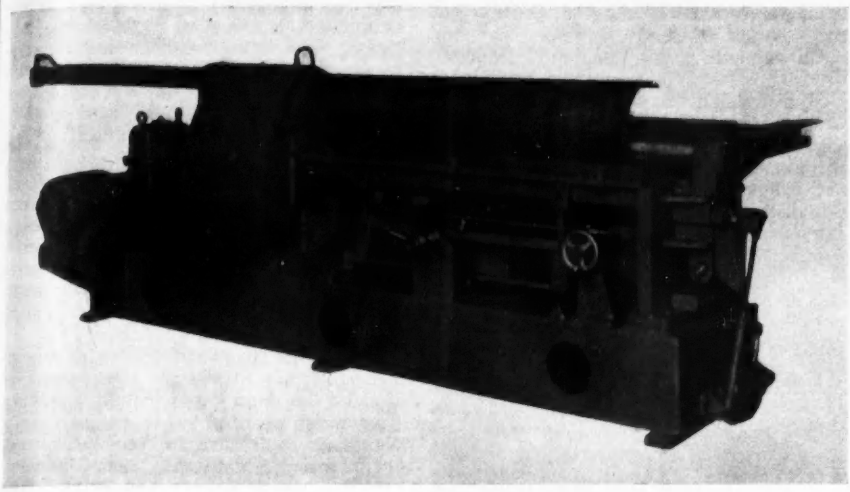
Four standard frame sizes make up the range of ventilated squirrel-cage motors shown here. They are built to the N.E.M.A. revised standard and cover an output range of ½ h.p. to 25 h.p.



20 cubic yard capacity rear dump truck with an unladen weight of over 30 tons

Automatic Circling Machine for Sheet Metal

AN automatic one-pass circling machine for the manufacture of sheet metal cylinders, which has been made by the Bronx Engineering Company, Ltd., Lye, near Stourbridge, is shown in one of the illustrations on this page. The machine is designed to produce mild steel cylinders from 5ft. long by 18in minimum diameter in 10-gauge material to 4ft long by 8in minimum diameter in 16-gauge material.



Circling machine for mild steel cylinders up to a maximum length of 5ft, in 10 gauge material. All movements are operated by pedal-controlled air cylinders.

The machine has a welded steel plate frame with a pair of high-carbon steel pinch rolls driven through gears mounted in one of the main housings. These gears are driven through a worm reduction unit by a 4 h.p. squirrel-cage motor. The bottom roll is adjustable to suit the thickness of the material, whilst the top roll has a swing-down bearing for the removal of finished cylinders. This swing-down bearing is operated by a compressed air cylinder.

A travelling table, which feeds the flat sheets into the pinch rolls, is air operated and fitted with an adjustable pusher bar. Sheets are bent with a forming bar which is designed to work close to the rolls, so that only a very small margin of flat is left at the edges of a cylinder. This forming bar is operated by air cylinders through toggle levers, and the bar can be quickly dropped to release a completed cylinder and rapidly returned to its operative position. Bar adjustments are provided to adapt the machine for different sheet gauges and cylinder lengths. An air-cylinder-operated pusher is fitted on the top roll for ejecting finished work when the end bearing has been dropped.

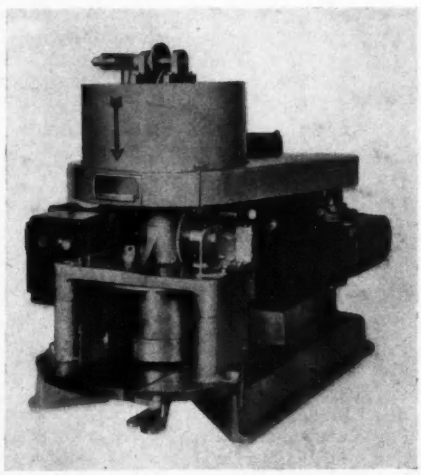
The operating valves for the compressed air cylinders are grouped on a floor plate for pedal operation, and as the air connections are made through flexible hoses this plate can be arranged in any position convenient to the operator. No manual effort is required in operating the machine and the makers state that the time of the operating cycle from loading to ejection of a cylinder is ten seconds.

Grinding Machine for Coal Samples

A MACHINE of " Hardgrove " design for grinding coal samples to determine their suitability for use in pulverised fuel systems is now being made by H. W. Wallace and Co., Ltd., 172, St. James's Road, Croydon, Surrey. This machine, to be seen in the accompanying illustration, conforms with the A.S.T.M. tentative standard D.409–37T, and at the suggestion of the British Coal Utilisation Research Association it has been designed to permit minor changes in the test which may be found desirable as a result of further research.

The bowl or container in which the coal sample is ground is a unit complete with pestle and balls which can be removed from the machine for filling and emptying. The lower section of this bowl in which the grinding operation takes place is detachable so that it can be removed and replaced, should it at any time become desirable to alter it. When a coal sample has been placed in the bowl it is placed on the machined slide on the base plate and pushed back into the working position. Then by a sideways movement of a locking lever at the bottom of the machine the bowl is raised and located in its operative position. The upwards pressure imparted on the bowl by the elevating lever presses its mouth firmly against a rubber sealing gasket to prevent the emission of dust during the subsequent grinding operation.

The required load of 64 lb is imparted by a ring-shaped weight on the top of the machine, and this load is applied by operation of a lever mechanism situated within the bore of the weight. As this lever is operated it serves also to engage the drive shaft with the pestle. When two buttons are then pressed the pestle is rotated at 20 r.p.m. for sixty revolutions and then stops.



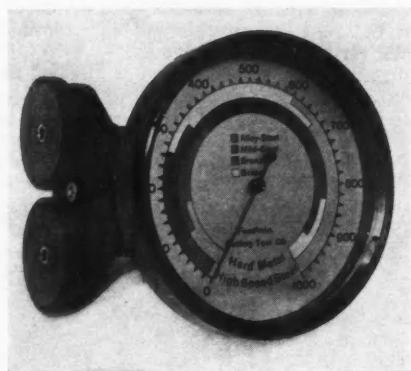
Machine for grinding coal samples to determine their suitability for pulverising

A ¼ h.p. geared motor at the rear of the machine drives the pestle through an 8mm roller chain giving a final speed reduction to the required 20 r.p.m. An electrically operated brake in the drive brings the mechanism to a stop within a quarter of a revolution when the sixty revolutions of the bowl have been completed. The pestle driving shaft is mounted in " Oilite " bushes between which oil-saturated felt is packed and a felt washer is fitted at the lower end of the shaft to prevent dust entering the bearings

Cutting Speed Indicator

PARTICULARS of a cutting speed indicator which is illustrated herewith have been received from Fred. Ferraris (Clerkenwell), Ltd., 14, Northampton Square, E.C.1. This instrument is of Swiss manufacture and is designed to show in feet per minute the correct cutting speed when machining different metals using high-speed steel or tipped tools.

An outer scale on the dial of the instrument is graduated with figures indicating cutting speeds up to 1000ft per minute. Inside this scale are two further scales, one for use when machining with high-speed steel tools and the other for use with hard metal or carbide tipped tools. These two inner scales are subdivided into sectors distinguished by colours. Each of the subdivisions covers an appropriate cutting speed range for alloy steel, mild steel, bronze and brass.



Cutting speed indicator for different metals when using high-speed or tipped tools

To use the instrument two driving rollers on a bracket at its rear are placed in contact with the rotating work piece. The indicator then moves round the dial to show the appropriate feed rate which should be used to obtain the highest economic cutting speed with the tool.

Flexible Hoses for Hydrogen Peroxide

CONCENTRATED solutions of hydrogen peroxide, particularly those containing over 75 per cent by weight of peroxide—known as high test peroxide or H.T.P.—are powerful oxydising agents which are decomposed by heat and by certain catalysts and will spontaneously ignite organic materials.

Increasing use of H.T.P. in industry and as a rocket fuel has led to special techniques for its safe storage and handling. Containers are usually lined with polythene or made from pickled high purity aluminium. Flexible hoses must also be made from materials which will not be attacked by peroxide and will not catalyse it. For some years P.V.C. has been in use for this purpose, but it has some serious disadvantages. At low temperatures it lacks flexibility and there is a tendency for unsupported hose to kink and entrap small quantities of H.T.P. which then decompose the hose. The Compoflex Company, Ltd., 26, Grosvenor Gardens, London, S.W.1, has developed designs which have now been approved by the Ministry of Supply. Samples of such tubing and ancillary components such as " O "-rings and gaskets were shown recently at a private exhibition in London.

The hoses consist of specially compounded P.V.C. with Terylene reinforcement. A wire supported hose of 1¼in bore diameter is available which will sustain a test pressure of 200 lb per square inch. A collapsible hose of the same size and for 150 lb per square inch test pressure is made of a layer of special P.V.C. between two layers of Terylene fabric, with a spiral channel in the bore lining which allows the escape of gaseous products of decomposition when the hose is kinked. A third design which is intended for working pressures up to 800 lb per square inch is in process of development. This hose has a ¾in diameter bore, and in addition to a stainless steel wire spiral has an external stainless steel braiding.

The Condon Case

BY OUR AMERICAN EDITOR

THE present greatly strained relations between the Government and scientists in the United States are not likely to be improved by the recent decision of Dr. Edward U. Condon to give up his fight for security clearance with the statement that " I do not feel there is any possibility of my securing a fair and independent judgment " at the present time. Dr. Condon is one of the most brilliant and best-known American scientists to-day. Beginning in 1927, he taught physics for ten years at Columbia, Princeton and Minnesota Universities. From 1937 to 1945 he was associate director of the Westinghouse Research Laboratories at East Pittsburgh. His investigation of the wave mechanics of radioactive decay was an important contribution to early nuclear physics, and his experiments on the separation of uranium 235 were of considerable value in the development of the atomic bomb. Throughout the existence of the " Manhattan District," the code designation of the wartime American atomic bomb project, he acted as a consultant to the U.S. Army. Soon after the end of the last war, in October, 1945, he was chosen by Henry A. Wallace, then U.S. Secretary of Commerce, to head the National Bureau of Standards. He was not long in this position, however, before he came under criticism. In July, 1946, an unidentified person, said to be a former employee of the " Manhattan District," wrote to the joint congressional committee on atomic energy suggesting that the committee examine the Federal Bureau of Investigation's record on Dr. Condon. J. Parnell Thomas, a Republican member of the House of Representatives, and, at the time, head of the un-American activities committee in the House, was also a member of the atomic energy committee. Representative Thomas wrote two magazine articles in 1947, saying, in effect, that Dr. Condon was a man to be watched. Dr. Condon wrote to Representative Thomas and asked to appear before his committee to answer any questions. Dr. Condon was not called before the committee, but the committee did start an investigation of him. At the same time, the loyalty board of the U.S. Department of Commerce began, at Dr. Condon's request, a parallel investigation. On February 24, 1948, the Department of Commerce panel cleared Dr. Condon of any suspicion of disloyalty. But on March 2nd, Representative Thomas's group issued a report asserting that Dr. Condon was " one of the weakest links in our atomic security." The basis of the charge was an excerpt from the F.B.I. report, which the committee had obtained, to the effect that Dr. Condon had associated " knowingly or unknowingly " with " alleged Soviet espionage agents," some of whom were specified. The committee made a determined effort to get President Truman to reveal to it the contents of the F.B.I. file on Dr. Condon. But the Secretary of Commerce, Averell Harriman, flatly refused on orders from the President. Dr. Condon repeatedly demanded the opportunity to testify on the charges against him, but he did not get the opportunity until September, 1952, long after he had resigned as director of the National Bureau of Standards to take up the position of director of research of the Corning Glass Works. Then he denied the charges under oath. Five months after this hearing, however, his clearance was revoked. This revocation was appealed, and in July of last year the Eastern Industrial Personnel Security Board of the U.S. Navy ruled that he might have limited clearance, which, in turn, was revoked by the U.S. Secretary of the Navy last October.

On announcing his resignation from the Corning Glass Works and his decision to give up his fight for security clearance, Dr. Condon issued a statement, saying, *inter alia*, that : " At the present time I do not feel there is any possibility of my securing a fair and independent judgment in a reconsideration of the decision by the Eastern Industrial Personnel Security Board of last July in favour of my security clearance. This Board had before it the reports of investigations stretching over eleven to fourteen years, since I worked on highly secret defence problems for the Government over a period from 1940 to 1951. In the course of that period, I have been cleared by such agencies as the Manhattan Project, the full membership of the Atomic Energy Commission, the Department of Commerce, and the military departments. I now am unwilling to continue a potentially indefinite series of reviews and re-reviews. I have therefore withdrawn my application for clearance, with the satisfaction that an objective and unbiased board which has conducted a complete hearing in this matter, which is also the highest board established by the three military departments for this purpose, has, after hearing me and studying the full record, decided that I am entitled to full clearance. I have served my Government in its efforts to preserve our national security for many years in both public and private capacities, and with a considerable degree of success if the testimony of my fellow scientists, available to the present authorities in this proceeding, is to be believed. In the course of these services my loyalty to this country and its Government has been clearly and formally established, and these proceedings raise no question on this score. If the duly constituted authorities of Government ever desire or request my services, they will be available and I will undergo any security examination and comply with any security procedures. I am happy to say that throughout all this difficulty the management of Corning Glass Works has shown confidence in me and my ability, and a willingness to support me in every procedural step to have my clearance re-established. The long-drawn-out clearance difficulties, however, began to affect my ability to perform my duties efficiently, and even to impair my health, so I began to consider other possibilities of employment. Aside from this, I have long felt a desire to get back entirely to fundamental research in physics."

What is most disturbing to American scientists and engineers in this unfortunate case is that there has been no release of information as to the reasons for the action against Dr. Condon last autumn, except for the statement of the Secretary of the Navy at the time that there was " sufficient evidence to warrant complete reconsideration." It would be fruitless to speculate as to what the new evidence might be. Dr. Condon's name had been brought into the Oppenheimer affair, but his last clearance was granted in July after that case had been settled. However, the reasons for his suspension may be perfectly sound, and no outsider can profess to know them. But many Americans are troubled by the procedure in this and other security cases under which a Government employee is apparently in permanent jeopardy. It seems to be the situation that no matter how many times he is cleared, he never can consider himself truly cleared. Such a procedure comes perilously close in spirit to the case of trying a man twice for the same crime, which is expressly prohibited by the American constitution. Dr. Condon says he has been cleared four times and is now " unwilling to continue a potentially indefinite series of reviews and re-reviews." One can sympathise with his feelings, especially in view of his claim that his clearance difficulties have begun " to affect my ability to perform my duties efficiently, and even to impair my health." Nevertheless, there are those who think it unfortunate that he has decided to give up the fight, retire from his present employment to work on private research and thereby make it unnecessary to continue the clearance effort. This is at best an unsatisfactory ending to the case, and it is certainly one calculated neither to reassure the public nor to alleviate that demoralisation of the American scientific community over which such eminent scientists as Dr. Vannevar Bush have so forcibly expressed their concern recently.

Isotope Training Course for Foreign Scientists at Oak Ridge

THE U.S. Atomic Energy Commission has completed arrangements for a special four-week course in isotope techniques for scientists and technicians from the fifty-three countries qualified to receive radioactive isotopes manufactured in the United States. It is the first of the several supporting projects which have been launched by the Commission in furtherance of President Eisenhower's proposal for an international atomic agency to be ready for operation. The special course will be identical with the training given six times a year to American scientists at the Oak Ridge installation and will open on May 2, 1955. It will be limited to thirty-two participants, and applications must be received by the U.S. State Department in Washington, D.C., by February 1, 1955.

This unclassified training in the use of isotopes has been available to scientists and technicians of friendly nations on a limited basis from its inception, but due to the popularity of the course in the United States, only a small number of persons from abroad could be accommodated in recent years. Therefore, in line with other steps being taken by the Commission in support of President Eisenhower's " atoms-for-peace " programme, this special session is being arranged. Provisions will also be made for admitting a limited number of qualified foreign research workers in subsequent sessions of the training course. The purpose of the Oak Ridge course, similar to that conducted by the A.E.R.E., is to permit qualified research workers and technicians to gain sufficient facility in the use of radioactive isotopes, to apply this important technique in their own work. During the four weeks' intensive training, the fundamentals in the use of isotopes are taught. The participants learn how to use and calibrate radiation detection instruments, how to purify and separate radioactive materials from inert or other radioactive materials, and how to apply them to a variety of chemical and biological research problems. Lectures in nuclear physics and chemistry and seminars are combined with laboratory work. It is believed that the 2000 men and women who have received this training since it began in 1948 have found it useful in a wide range of scientific, medical, agricultural and industrial fields. To qualify for enrolment, applicants must have a bachelor's degree ; adequate training and experience in the field in which they propose to use isotopes, and an understanding of the English language.

Launching of Aircraft Carrier U.S.S. "Forrestal"

THE aircraft carrier U.S.S. "Forrestal" was launched at the yard of the Newport News Shipbuilding and Drydock Company at Newport News, Virginia, on December 11th. The 59,900-ton vessel, which has an overall length of 1036ft and an extreme width across her flight deck of 252ft, is believed to be the largest warship in the world, and its maximum displacement approaches that of the "Queen Elizabeth." The sponsor of the carrier was Mrs. James V. Forrestal, the widow of the first Secretary of Defence of the United States, for whom the vessel was named. The ceremony took place in the shipyard's No. 11 building dock, which was the only one large enough to accommodate such a gigantic vessel. The launching was accomplished by a flotation procedure in which the graving dock was flooded and the vessel made water-borne prior to the actual christening. This was the same procedure followed by the yard in the launching of the S.S. "United States" in 1951.

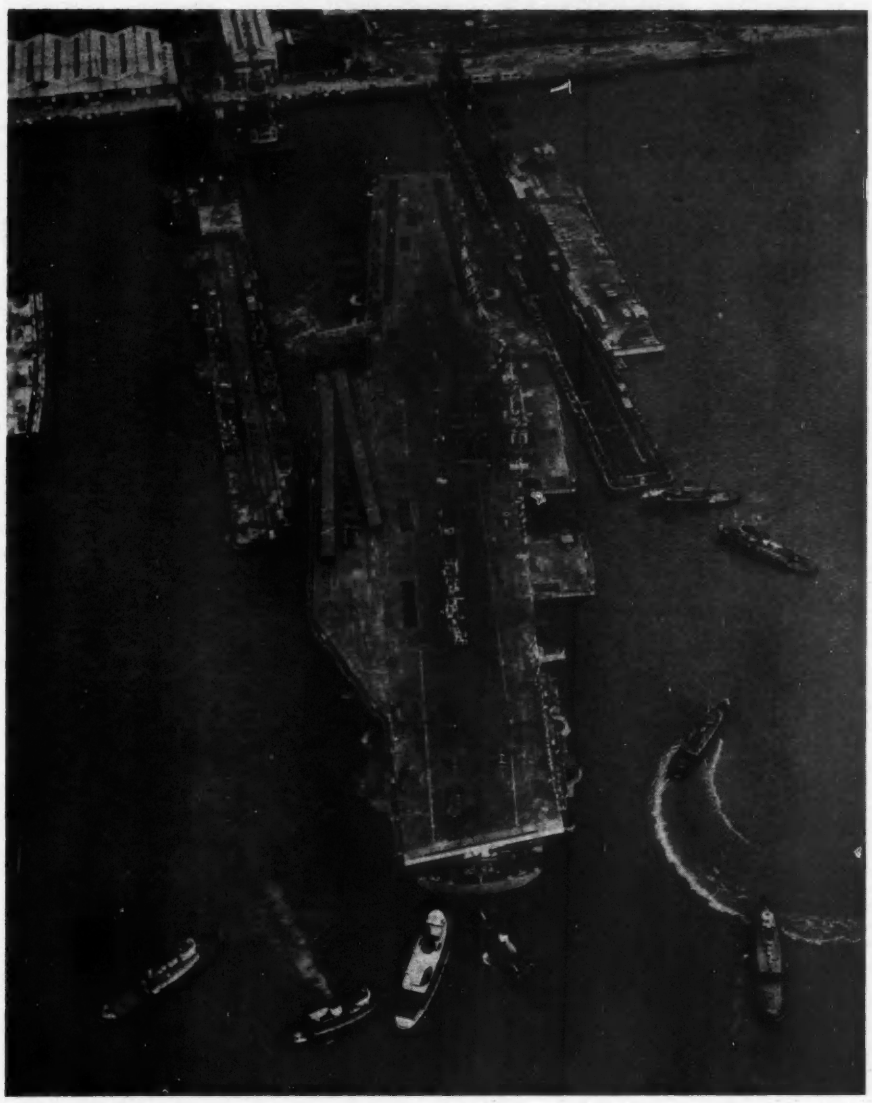
The large carrier is the first of a series of ten such vessels sought by the U.S. Navy to accommodate the fast new jet fighter and light bomber aircraft, some of which will be capable of delivering atomic bombs to any part of the world. Three other vessels of the "CVA" class already have been ordered and a fifth is being requested in the U.S. Navy's new budget. Of the four ordered, the Newport News yard is building two, and the New York Naval Shipyard the remainder. The "Forrestal," which is scheduled for commissioning this autumn, incorporates many points of advanced design. It has a canted deck area of nearly 4 acres which enables aircraft to land at a slightly oblique angle to the fore and aft centre line of the ship. Thus, a pilot who has made a bad approach can "gun" his aircraft for another try without endangering aircraft and personnel on the forward flight deck. Because of the additional landing area, a fixed island structure was used, instead of the retractable unit originally called for. The canted deck arrangement is such that take-off and landing operations can be handled simultaneously.

The keel for the "Forrestal" was laid on July 14, 1952, and since that time thousands of workmen have fabricated, assembled and constructed some 50,000 tons of steel to form this great vessel. The vessel has a number of structural innovations which make her different from other large carriers. One of these is that her flight deck is the strength deck. On both the "Midway" and "Essex" classes of American carriers, the main or hangar deck is the strength deck. Normally, the flight deck is built with expansion joints so that it is not a part of the ship's overall strength girder. By contrast, the flight deck on the "Forrestal" is a continuous fore-and-aft strength deck. The deck is 1½in steel plate which will have no difficulty in withstanding the heat of jet blasts.

While the "Forrestal" was being built the U.S. Navy was experimenting with the canted flight deck, following earlier work by the Royal Navy. These tests were carried out aboard the carrier "Antietam" and proved so successful that the principle was adopted for the "Forrestal." Instead of landing straight in, aircraft will fly in at a 10·5 deg. angle from the starboard quarter of the ship's cruiser stern. This cant or angle on the flight deck is one of the reasons for the extreme width of the present vessel. The other advantage is that on the starboard side of the ship outboard of the island aircraft can be brought up from below without interfering with operations on the centre line of the deck. From the air the "Forrestal" does not appear to be a large ship because of the fact that her length of 1036ft is only slightly more than four times that of her extreme width of 252ft. Her island, which is the height of a ten-storey building is almost lost on her enormous flight deck. Another unusual aspect of the ship will be her folding masts. The tallest of the masts extends up to a height of 187ft from the ship's water line. This is about 60ft too high to clear the Brooklyn Bridge in New York. Thus, both her masts will be installed to fold, mainly to facilitate travel to and from the Brooklyn Naval Shipyard.

The "Forrestal" has four steam catapults that will enable her to launch aircraft faster than any other American carrier afloat. Her heavy-duty hydraulic arresters will stop one of to-day's 70,000 lb jet aircraft within 150ft after it hits the deck at a speed of 100 m.p.h. The steam catapults employed were commissioned at the U.S. Naval Air Material Centre in Philadelphia in December, 1953, and are similar to those originally developed by the Royal Navy. With an increased launching power estimated at between five and six times greater than current hydraulic models, these new catapults can launch high-performance jet aircraft even when a carrier is headed down wind or is in a dead calm. Operating steam for the catapults is provided by the conventional ship's boilers which eliminates the necessity for special petrol, oil, powder or compressed air facilities. The maximum operating pressure provided by the boilers is 550 lb per square inch and the energy developed from the catapult is 33,200,000ft-lb. The catapult consists of two long slotted cylinders lying side by side directly under the flight deck. It has no rams or purchase cables. Two pistons in the cylinders are solidly interconnected by a cross piece which passes through the slots in the cylinders. The launching hook, which connects to the aircraft towing bridge, is situated at the mid-point of the piston and extends up through a slit in the flight deck. Steam to operate the catapult is collected in a steam accumulator from the ship's boilers. A launching valve is the means used to control the steam for each individual shot.

A Westinghouse steam turbine installation rated in excess of 200,000 s.h.p. will be geared to four 22ft diameter five-bladed propellers and is expected to enable the vessel to reach speeds of "over" 30 knots. The ship will accommodate up to 100 aircraft, including both jet-powered and propeller-driven machines.

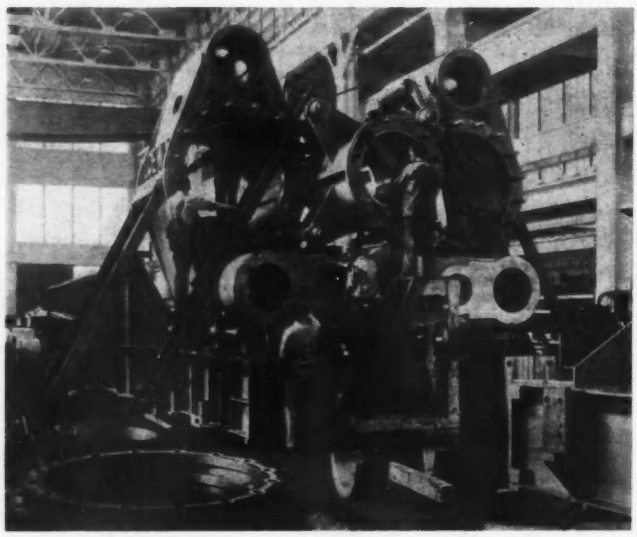


Aircraft carrier U.S.S. "Forrestal" being moved to fitting out basin after launching.

AWARD OF THE WRIGHT BROTHERS MEMORIAL TROPHY.—Dr. Theodore von Karman has been awarded the Wright Brothers Memorial Trophy for 1954. According to Thomas G. Lamphier, Jr., the president of the National Aeronautic Association, Dr. von Karman was selected because of his "significant public service as a civilian of enduring value to aviation in the United States." In particular, Dr. von Karman was cited by the Association for his basic contribution to the development of the first supersonic wind tunnel project in the United States in 1938, and for initiating the first jet propulsion and rocket motor project for the U.S. Air Force at the California Institute of Technology the same year.

Large Hydraulic Extrusion Presses

SEVERAL large extrusion presses are being installed in the heavy press building under construction at the Torrance works of the Harvey Machine Company, Aluminum Division, in California. Planned as a joint participation project under the U.S. Air Force heavy press programme, the installation is scheduled for completion during the first quarter of this year. The facility is a major phase of an overall expansion programme and will adjoin the company's existing extrusion mill. In addition to a battery of extrusion presses, the new structure will house equipment for heat-treating, ageing, annealing, hydraulic stretch-straightening and auxiliary finishing. The heavy extrusion presses were designed primarily to produce large " one-piece " airframe members. With its 12,000-ton hydraulic press, the company will be able to produce aluminium alloys in shapes up to 80ft long and 25½in wide. By utilising special extruding techniques, the firm expects to be able to produce panel shapes in single sections as wide as 60in. The availability of heavy press aluminium extrusions with greater cross sections, weights and lengths will allow the American aircraft industry to reduce fabricating and machining time and effect substantial manufacturing economies. The shop erection of an 8000-ton extrusion press by the Loewy Construction Company, of New York, is shown in the accompanying illustration. In addition to the one being supplied to Harvey Aluminum, two such presses are also being supplied by the Loewy Construction Company to the Kaiser Aluminum and Chemical Corporation as part of the U.S. Air Force programme.



Shop erection of 8000-ton hydraulic extrusion press

Aluminium-Steel Bonding Process

A PROCESS known as " Alumicoat," by which pure aluminium, or alloys of aluminium, may be bonded to ferrous metals, has recently been made commercially available in the United States. It is said to provide a high degree of protection to steel parts from both chemical and elevated temperature corrosion. The Arthur Tickle Engineering Works, Incorporated, of Brooklyn, New York, is the commercial licensee for this process and has constructed a new building to accommodate the equipment necessary to handle, in production quantities, both large and small articles. This method of bonding aluminium to steel was originally developed by the General Motors Corporation under the name of " Aldip." Although aluminium alloys can be used as the coating material, it has been found that pure aluminium offers greater resistance to the attack of industrial gases and other corrosive media, especially those containing sulphuric compounds. The aluminium, in either case, penetrates the steel to a depth of 0·0015in to 0·002in, while a protective coating 0·001in to 0·0005in thick remains on the surface. Tests have shown that adequate protection against oxidation still remains at temperatures as high as those to which the base metal might be heated during use. At temperatures exceeding the melting point of the aluminium the coating diffuses into the steel, forming an intermetallic compound of iron and aluminium. This diffused coating acts as a refractory material that provides the steel with maximum protection against high-temperature scaling.

Cleaning in an electrolytic caustic salt bath is the first step in the " Alumicoat " process. The parts are immersed in this bath, which is maintained at a temperature of approximately 950 deg. Fah. for a period ranging from one to thirty minutes, depending upon their surface condition. After being removed the parts are neutralised by lowering them into a bath of dilute hydrochloric acid. A steam bath follows to remove all traces of impurities from the surface of the metal. All areas to be free of coating are then masked off by painting with titanium oxide carried in a vehicle of sodium silicate and water. A proper bonding of the aluminium to the steel base metal is ensured by submerging the parts in a molten salt bath consisting of sodium chloride, potassium chloride, and cryolite (sodium-aluminium fluoride). This molten flux is heated to an operating temperature ranging from 1300 deg. to 1325 deg. Fah in an Ajax-Hultgren salt bath furnace utilising immersed electrodes. The parts lowered into the heated flux are not only cleaned but also brought up to proper heat for plating. At the bottom of the furnace is a layer of molten aluminium. The purpose of the aluminium layer is twofold. In the first instance, the presence of the molten metal has an advantageous effect on the performance of the flux. Secondly, small parts may be lowered into the bottom layer for plating rather than into a separate furnace. The hot fluxed parts are then lowered for final plating into a low-frequency induction furnace, which contains molten aluminium only. The aluminium is maintained at a temperature of approximately 1250 deg. Fah. Since the parts have been preheated to 1300 deg. Fah. in the flux bath, dipping into the molten aluminium results in a continuous bonded coating upon contact, regardless of part design. Any excess aluminium may be removed by rinsing in the fluxbath. The coating of aluminium remaining on the surface may be further diffused into the parent metal by heating it above the melting point of the aluminium. This operation may be carried out to the point where all the surface aluminium will be absorbed by the steel.

Instrument for Smoke Density Measurements

AN instrument known as the " M.S.A. Smokescope " has been developed by the Mine Safety Appliance Company, of Pittsburgh, Pennsylvania, to measure smoke densities. The instrument can be used to determine whether or not fuel is being properly burned, since excessive smoke indicates that it is not. In this respect, it is hoped that industry can put the instrument to work to obtain greater boiler efficiency in addition to improving its community relations through reduced air pollution. Using the instrument, observers are able to view a standard reference disc, shaded to correspond with degrees of smoke density, against the background of a smoke plume. The instrument is used to determine the relative density of smoke rising from a chimney as shown in the accompanying diagram. The observer views the smoke through apertures *C*, *D* and *G* in the barrel *A*. Light from an area adjacent to the stack is transmitted through the reference disc *H* in the barrel *B* to the surface of the mirror *E*. From this mirror an image of the reference disc is projected through the lens *F* on to the image mirror. Here it can be compared with the smoke seen through the apertures. The centre portion of the disc is blocked by an opaque disc *J*.

The lens used to project a virtual image of the reference film disc also serves to intensify the light in the reference standard optical path, compensating for the light loss at the reflecting surfaces. Field and laboratory tests were made by smoke control experts with early models of the instruments, in which variations in size and shape of apertures, reference discs and light blocks were tried. These tests gave no indications of error caused by background lighting of the smoke or ambient light near the observer. The need for such an instrument arose from the difficulties surrounding the old method used in America which employed the " smoke chart." Observers used to set up a chart 50ft from the point at which they stood to check the amount of smoke issuing from a chimney. The chart was made up of squares of black line rulings, each square having a fixed percentage of black and white areas which, at the specified distance of 50ft, merged into shades of grey. The smoke under observation was then compared with the squares and the one which most closely matched the shade of the smoke was noted. While far from perfect, the chart system still is the foundation of all past experience in gauging amounts of smoke and the basis for all existing American smoke-control legislation. But it has distinct disadvantages, such as its inconvenience, the necessity to refocus the eye in looking at the smoke and then the chart, the variation in readings caused by the intensity and incidence of light on the smoke, and the variation in readings caused by differences in the illumination of the chart. It is claimed that all these disadvantages are overcome in the " Smokescope." The design of the instrument eliminates any possible interference of ambient light because the user views the smoke through apertures which limit the field of vision to the subject, and there is no necessity to shift the eye from smoke to chart.

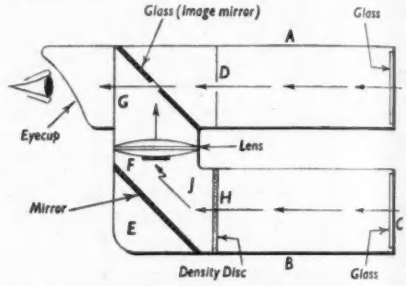


Diagram showing method of smoke density measurement

Industrial Nuclear Power Reactors

A PROPOSAL by the Kaiser Engineers Division of the Henry J. Kaiser Company of Oakland, California, to study the feasibility of nuclear power reactors has been approved by the U.S. Atomic Energy Commission. The firm will survey technology already developed in the power reactor field to determine the engineering and economic practicability of designing, constructing and operating a power-producing reactor. The company also will examine the technical problems related to building such reactors in the next few years and determine what research and development will be necessary before actually undertaking construction of a reactor. The company will spend an estimated 100,000 dollars in the study which is expected to take one year.

Industrial and Labour Notes

Changes in Wage Rates

The Ministry of Labour has recently made an analysis of the changes in wage rates which came into operation during 1954. It shows that by the end of the year 10,117,500 workers had received increases in wages aggregating £3,487,600 a week. Thus, the Ministry says, there was an increase in the average level of weekly rates of wages of about 4½ per cent last year, compared with 3 per cent in 1953, and 6 per cent in 1952. At the end of December the index of weekly wage rates (June, 1947=100) was 144 for all workers, compared with 138 a year earlier. The average level of retail prices, it is stated, as measured by the interim index, rose by about 4 per cent during the year.

In the three industrial groups, classified as engineering, shipbuilding and electrical goods, vehicles, and metal goods "not elsewhere specified," there were last year 2,353,000 workpeople who received wage increases aggregating £823,100. It will be recalled that in April last in the engineering and allied industries there were increases for adult male timeworkers and payment-by-results workers of 8s. 6d. a week for skilled men, 7s. 6d. a week for intermediate grades, and 6s. 6d. for unskilled grades, and increases of 5s. 8d. a week for women workers of eighteen and over. In shipbuilding and ship repairing there were wage increases last April of 8s. 6d., 7s. 6d., and 6s. 6d. for men, and of 5s. 8d. to 8s. 6d., according to occupation and length of service, for women of twenty-one and over.

The Ministry's analysis also shows the movement of wages in the transport industry last year. In January, 1954, in the railway service there was an increase of 6 per cent on the wage rates operating prior to December, 1953. From October last, revised schedules of rates of pay were adopted for the employees of British Railways, which resulted in increases of up to 26s. a week for locomotive running staff, according to grade and service, and up to 6s. 6d. a week for other conciliation staff. Trolleybus, bus and coach drivers and conductors and certain maintenance staff employed by London Transport received a wage increase of 7s. a week in January, 1954. The operating staffs of municipal tramway and bus undertakings had an increase of 3s. a week in March, and in November last there were further increases of 8s. a week for drivers and conductors and of 7s., 6s. or 5s. a week, according to grade, for semi-skilled and unskilled workers in depots and garages. For the operating staffs of company-owned motor omnibus undertakings there was an increase of 4s. a week last February and a further increase of 3s. a week in March. The statutory minimum rates for adult workers engaged in goods transport by road were increased by 4s. a week in January, 1954, and by a further 3s. last October.

Wages and Skill

The subject of wage differentials in the engineering industry was referred to on Monday last by Captain A. R. S. Nutting in his chairman's statement at the annual meeting of Westinghouse Brake and Signal Company, Ltd. He mentioned the engineering wages claim which had recently been lodged, saying that, whatever the outcome might be, it was clear that if further increases were agreed upon, they would increase the cost of production, thus making it more difficult to meet competition in world markets.

Captain Nutting went on to say that the engineering industry as a whole had become aware of the increasing shortage of skilled personnel. He held the view that the narrowing of the gap between the pay of the skilled and the unskilled in recent years had tended to discount technical ability. To-day, Captain Nutting continued, the engineering industry was spending vast sums of money in training unskilled and semi-skilled personnel at the time when they were first engaged. That, he agreed, was all to the good, but he nevertheless thought it unfortunate that so many of the unskilled, or semi-skilled, could, within so short a space of time and with so little experience, reap rewards which did not differ greatly from those of the highly skilled.

Captain Nutting suggested that the time had come when the importance and value must be recognised of personnel who were above the common average, and who possessed skill and abilities which resulted in British products being regarded throughout the world as above average. Skilled workpeople contributed very largely to the success of this country's sales efforts in the world markets. He hoped, therefore, that in engineering wage negotiations the great value of those with skill and outstanding technical ability would be recognised. The position ought to be reached, Captain Nutting added, where it could be truly said that it was worth while for any man or woman in industry to make the extra effort to acquire skill and technical ability.

Industrial Production

The central statistical office of the Treasury has estimated that the index of industrial production (1948=100) for the whole of last year in all industries was 128, compared with 121 in 1953. The figures for November last, which have now been issued, put the index for all industries at 137, compared with a revised figure of 136 for October. In the comparable months of 1953 the index figures for all industries were 133 in November and 131 in October. According to the Treasury's statement, the production index in the manufacturing industries alone last November was 142, compared with 136 a year earlier, in the gas, electricity and water supply industries 160, compared with 146, and in mining and quarrying it was 118, compared with 119 in November, 1953.

Industrial Disputes

During the month of December there were 151 stoppages of work through industrial disputes in progress in the United Kingdom, with the result that there was an aggregate loss of 82,000 working days by 33,500 workpeople. The Ministry of Labour has stated that the total number of stoppages through disputes last year was 1994, and that 446,900 workers were involved in them, with a consequent loss of 2,470,000 working days. The actual number of working days lost through disputes was thus higher than in any year since 1945.

The majority of the work stoppages through disputes last year occurred in the coal mining industry. These stoppages accounted for nearly one-fifth of the aggregate loss of time last year and for about two-fifths of the total number of workers involved in all stoppages, which indicates, of course, that most of the stoppages in the coal mining industry were of short duration. Dealing with disputes in other industries last year, the Ministry of Labour recalls the stoppage of work in the ship-repairing industry, in which about 8700 workers in London and the Thames Estuary were involved. The stoppage, which arose out of a protest by electricians against the order of discharge of certain workers, began in September and went on until the beginning of December. It resulted in the loss of about 485,000 working days. Another stoppage of work last year, mentioned by the Ministry, is that in which 400 workers in the light engineering industry in Glamorgan were involved. It continued from July until October and caused a loss of about 22,000 working days. This stoppage arose from a claim that semi-skilled workers in the tool room should be paid skilled tool room rates.

The stoppages of work in the transport industry last year caused an appreciable loss. The largest single stoppage of work in the year was, in fact, the dock strike, which lasted for the month of October. It involved about 26,000 dockers in the Port of London, where approximately 530,000 working days were lost, and a further 196,000 working days were lost by 19,000 dockers in other parts of the country. Another stoppage of work in the transport industry last year was that of 2700 locomotive drivers and firemen employed on British Railways, who were protesting against the introduction of additional lodging turns. About 24,000 working days were lost, principally in the Western Region of British Railways.

Duty-Free Entry of Machinery

In a written reply last Monday, the President of the Board of Trade stated that he had appointed a consultative committee on the duty-free entry of machinery, in accordance with a recommendation of the Wilson Smith committee. The chairman of the committee is an Under-Secretary of the Board of Trade, the other members being Mr. A. P. H. Aitken, Mr. R. W. Asquith, Mr. M. A. H. Bellhouse, Mr. W. Ellison, Sir Laurence Merriam, Mr. A. York Saville, and Mr. J. Tanner. The function of this committee, the reply stated, would be to keep under review the broad policy followed by the administering departments, including the basic criteria laid down for the duty-free admission of machinery, and to represent industry's view to the departments. The reply added, however, that the committee would not in any sense be an appellate tribunal considering appeals on individual applications, and would have no executive responsibilities.

F.B.I.'s Budget Representations

The Federation of British Industries has published the representations on the forthcoming Budget, which it has recently submitted to the Chancellor of the Exchequer. The fiscal changes which the Federation considers to be most important are : a reduction in the standard rate and lower rates of income tax ; a reduction in the overall burden of profits tax ; an increase of the investment allowance on industrial buildings to 20 per cent ; a substantial reduction in all rates of purchase tax ; a reduction of the estate duty on private limited companies, and a reduction of the duty on fuel for the road transport industry.

In detailing these suggestions, the Federation says that British industry must increasingly modernise its equipment and processes, reduce its production costs and develop new products capable of being sold overseas. This involves, it is urged, capital investment in risk enterprise, which means long-term and substantial expenditure by industry on productive assets. The F.B.I. goes on to say that the present very high rates of taxation must be reduced substantially to induce adequate investment in existing and new productive enterprises, especially in those which will enable Britain to compete successfully in the world's export markets. Some of our main competitors, the F.B.I. claims, are enjoying or are promised a substantial reduction in direct taxation. The object of fiscal policy in the coming year, therefore, should be to enable British industry both to raise its output and to keep down its costs of production to levels which will enable it to meet foreign competition more effectively.

Coal Production and Consumption

The Ministry of Fuel and Power has stated that saleable coal production in the first four weeks of this year, ended January 29th, amounted to 17,635,400 tons. This was made up of 17,063,900 tons from the deep mines and 571,500 tons from opencast workings. In the first four weeks of last year coal output amounted to 18,363,400 tons, but more was then gained from opencast workings, and the greater part of the New Year holiday fell within the period calculated as the last week of 1953.

Output of deep-mined coal last week amounted to 4,397,600 tons and was thus about 9000 tons greater than in the comparable week last year. The total number of wage earners on colliery books on January 22nd was 708,700, of whom 290,300 were face workers. Inland coal consumption continues to increase and in the first three weeks of this year amounted to 14,375,000 tons, which was about 500,000 tons more than in the corresponding period of 1954. Total distributed stocks on January 22nd were 13,223,000 tons, compared with 16,137,000 tons a year earlier.

Personal and Business

Appointments

MR. SIDNEY HILL has joined the sales staff of Acme Conveyors, Ltd., with headquarters at 11, Union Road, New Mills, Stockport.

MR. R. J. L. FISH has been appointed assistant to the sales and executive director of British Straddle Carrier Company, Ltd., 7, Chesterfield Gardens, Curzon Street, London, W.1.

MR. KENNETH TEALE has been appointed chief efficiency engineer of Short Brothers and Harland, Ltd., Belfast. He has been the company's machine tool design engineer since 1951.

THE PRESIDENT OF THE BOARD OF TRADE has appointed Mr. Misha Black, Professor R. Y. Goodden, Mr. W. Johnstone and Mr. J. M. Richards to the Council of Industrial Design.

MR. R. H. SEMPLE, regional manager in Scotland for British Insulated Callender's Cables, Ltd., has accepted an appointment with British Insulated Callender's Cables (Australia) Pty., Ltd.

GEORGE SALTER AND CO., Ltd., West Bromwich, states that Mr. P. J. Miles has been appointed to represent its balance division in the north London area, in succession to Mr. E. T. Scriven.

THE BRITISH TRANSPORT COMMISSION has announced the following headquarters appointments :—Mr. J. B. Garrett, assistant traffic adviser (freight), and Mr. J. E. M. Roberts, assistant traffic adviser (passenger).

LANCASHIRE DYNAMO AND CRYPTO, Ltd., states that Mr. A. J. Beanland, general manager of the Trafford Park Works, and Mr. C. F. Jackson, general manager of the Willesden works, have been elected directors.

COMMER CARS, Ltd., Luton, announces the appointment of Mr. A. L. Markham as works manager of its new factory at Dunstable. Mr. P. D. Ratcliffe has been appointed Commer-Karrier sales promotion manager.

DUNLOP, Ltd., announces the appointment of Mr. Charles Hemm as director of projects (general rubber goods). For the past six years he has been general works manager and a local director at the firm's Cambridge Street factory in Manchester.

MR. G. G. BALDWIN has been appointed agricultural machinery adviser in the tractor division of the David Brown Corporation (Sales), Ltd., Huddersfield. Mr. A. J. Warde Dixon has been appointed export sales manager in the David Brown tractor division.

MR. F. C. E. GOSS, technical assistant and signal engineer of Westinghouse Brake and Signal Company, Ltd., has accepted an appointment from the United Nations Technical Assistance Administration to serve as the principal lecturer at the United Nations Railway Training Centre, Lahore, Pakistan. This appointment is initially for one year.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby, announces the appointment of Mr. H. L. Satchell as deputy director of manufacture. He joined the company as an apprentice in 1922, has been manager of the Rugby works since February, 1945, and was appointed a director in March, 1949. Mr. Satchell will be succeeded as manager of the Rugby works, on March 1st, by Mr. H. E. Cox, M.I.E.E., who has been manager of the B.T.H. Willesden works since 1946.

THE PATERSON ENGINEERING COMPANY, Ltd., Windsor House, Kingsway, London, W.C.2, announces the appointment of Mr. John V. Sheffield as chairman, and of Mr. O. C. Kerrison as managing director. Mr. S. W. Burrells has been appointed secretary of the company. These appointments follow the retirement of Sir William Paterson from the offices of chairman and managing director and from the board, after fifty-three years in the service of the company which he founded.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, has announced the appointment of Mr. A. J. R. Veale as superintendent in the process and rate department, in succession to Mr. W. A. Bull. Mr. Bull continues to assist the works management on special problems. Mr. M. O. Short has been appointed assistant superintendent in the process and rate department. The company also announces the appointment of Mr. R. H. Kelsall as assistant chief electrical engineer in the electronic control department.

Business Announcements

THE MORSE CHAIN COMPANY, Ltd., Letchworth, Herts, states that it will in future be known as Borg-Warner, Ltd.

MR. E. S. PRESTWICH, managing director of J. A. Prestwich Industries, Ltd., is making a tour of South Africa, Australia and New Zealand.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has moved its London branch sales office to 10–14, White Lion Street, N.1 (telephone, Terminus 8696 and 0372).

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY has moved its publicity department to 14–16, Cockspur Street, London, S.W.1 (telephone, Whitehall 4444).

HALL HARDING, Ltd., Stourton House, Dacre Street, London, S.W.1, states that Mr. A. W. Bartlett, general manager of the export section, has left London for a tour of Africa.

THE JOHN THOMPSON group of companies has moved its Newcastle office to permanent quarters at "A" Floor, Milburn House, Newcastle upon Tyne, 1 (telephone, Newcastle 29720).

ACME CONVEYORS, Ltd., 181–183, Knightsbridge, London, S.W.7, states that it has opened a drawing-office and sales department at 10, Vicarage Place, Walsall, Staffs, under the control of Mr. F. Willis.

SHEEPBRIDGE ENGINEERING, Ltd., Chesterfield, states that the name of Compression Ignition, Ltd., one of its subsidiaries, has been changed to Twiflex Couplings, Ltd. This company continues to operate at The Green, Twickenham, Middlesex.

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY states that Captain D. G. H. O. Baillie, at present in command of the liner "Himalaya" and who has been commodore of the fleet since 1953, is to retire at the end of his present voyage.

GRIFFIN AND GEORGE, Ltd., states that in association with Grundy (Teddington), Ltd., a new company entitled Grundy Equipment, Ltd., has been formed. The new company will specialise in the production of metal laboratory furniture and Griffin and George, Ltd., will act as its sole selling agent.

THE CHAMBER OF SHIPPING OF THE UNITED KINGDOM announces that at a council held last week, Mr. A. I. Anderson, the chairman of the Orient Line, was nominated for election as president, and Mr. K. R. Pelly, chairman and managing director of William France, Fenwick and Co., Ltd., was nominated as vice-president.

ENGLISH STEEL CORPORATION, Ltd., Sheffield, announces the formation of five subsidiary companies, as follows :—English Steel Forge and Engineering Corporation, Ltd., English Steel Rolling Mills Corporation, Ltd., English Steel Castings Corporation, Ltd., English Steel Spring Corporation, Ltd., and English Steel Tool Corporation, Ltd. Mr. F. Pickworth is the chairman of each of the companies.

Contracts

SELF CHANGING GEARS, Ltd., announces that the State Railways in Norway and Sweden have placed repeat orders for self-changing Wilson gearboxes, totalling twenty-five for Norway and eighty-five for Sweden.

HENRY ROBB, Ltd., Leith, has contracted to build, for the Chine Shipping Company, Ltd., a single-screw motorship of about 5500 tons deadweight. The ship, which will be a repeat of the M.S. "Longfellow," will have main and auxiliary machinery supplied by Sulzer Brothers, Ltd., Winterthur.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has received an order from Glen and Co., Ltd., for a cargo steamer of 2700 tons deadweight. An associated company, Alexander Hall and Co., Ltd., will build the ship, which will have a length between perpendiculars of 275ft, a breadth of 44ft, a depth moulded of 19ft 9in, and will be propelled by a double-compound steam engine developing 1450 i.h.p. and taking superheated steam from two boilers.

THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD has placed a contract for the construction of a dam at Loch Fannich, Ross-shire, with John Laing and Son, Ltd. The dam at Loch Fannich will be a rock-fill structure, 2400ft long and 30ft high, with a central section of mass concrete gravity dam. It will raise the water level of the loch by about 20ft and will increase the available storage by an amount equivalent to 3,000,000 units, giving a total of 82,000,000 units. The civil engineering consultants for the scheme are Sir Alexander Gibb and Partners.

THE BRITISH ELECTRICITY AUTHORITY has placed contracts during the past month for power stations, transforming stations and transmission lines, totalling £2,341,380. The principal contracts include : Marchwood power station, near Southampton, structural steelwork (Alex. Findlay and Co., Ltd.); Castle Donington power station, near Derby, 3·3kV indoor airbreak auxiliary switchgear (British Thomson-Houston Company, Ltd.); Drakelow B power station, Burton-on-Trent, one 125MVA, 13·8/295kV generator transformer (British Thomson-Houston Company, Ltd.); Willington A power station, near Derby, twelve auxiliary transformers (Yorkshire Electric Transformer Company, Ltd.), and four booster and four boiler feed pumps (Mather and Platt, Ltd.); Lincoln power station, structural steelwork (Pierson and Co., Ltd.); Keadby power station, Yorks, ash ponds (Sir Robert McAlpine and Sons (Midlands), Ltd.); Wakefield power station, Yorks, two natural draught cooling towers (Davenport Engineering Company, Ltd.); Capenhurst substation, Cheshire, nine 10MVA, 132/3·3kV transformers (Ferranti, Ltd.); Dunston substation, near Newcastle upon Tyne, one 75MVA, 133/66kV main and one 140kVA auxiliary transformers (Ferranti, Ltd.), and Rochdale–Kearsley–Rawtenstall, 132kV overhead line (W.T. Henley's Telegraph Works Company, Ltd.).

Miscellanea

VENEZUELAN DESTROYERS.—The last of the three destroyers ordered from Vickers-Armstrongs, Ltd., for the Venezuelan Navy was named "Aragua" and launched from the Barrow shipyard of the company on Thursday, January 27th. The "Aragua's" two sister ships are now in service, the "Nueva Esparta" having been launched on November 19, 1953, and the "Zulia" on June 29, 1953.

OBITUARY.—We have learned with regret of the death of Mr. W. A. Foulis, A.M.I.C.E., which occurred recently at the age of eighty-one. Mr. Foulis was chief assistant engineer of the Tyne Improvement Commission from 1915 to 1936, having joined the engineering staff of the Commission in 1898. Prior to that he was for four years an assistant resident engineer to the Clyde Navigation Trust, being engaged principally during that time on the construction of a new graving dock at Govan.

EMPIRE MINING AND METALLURGICAL CONGRESS.—The Empire Council of Mining and Metallurgical Institutions states that the sixth congress is to be held in Canada during 1957, by invitation of the Canadian Institute of Mining and Metallurgy. Full particulars are expected to be circulated within the next few months to members of the principal mining and metallurgical societies in the Commonwealth. Meanwhile, some preliminary information is available from the Empire Council of Mining and Metallurgical Institutions, 438, Salisbury House, London, E.C.2.

GENERATING PLANT.—Dale Electric (Yorkshire), Ltd., Filey, Yorkshire, has announced the introduction of a range of generating sets incorporating Ruston engines. All sets are of monobloc construction with integral switchboard. The smallest are powered by a Ruston "YB" engine, of 3·5kVA and 7kVA capacity, and are offered for either automatic, semi-automatic or hand start. The remainder, of from 17kVA to 90kVA and driven by Ruston "YC" and "5YE" and "6YE" engines, respectively, can be arranged for remote control, normal electric starting, or mains failure operation. Low oil pressure and high water temperature safety devices are provided on the smaller sets.

COLD AND MOULD-RESISTANT PAINTS.—Two new paints are now being made by Allweather Paints, Ltd., 36, Great Queen Street, London, W.C.2, one for low-temperature applications and the other for mould-resistant use. The firm's "Pitan" cold-temperature resistant paint is designed to withstand temperatures as low as minus 60 deg. Fah. and still remain flexible. It incorporates a special cold-resistant plasticiser and provides a surface resistant to acid and alkali attack and the effects of brine and ammonia. The rubber-based mould-resistant paint incorporates a mercurial fungicide which does not cause embrittlement or other deterioration of the paint film. This mercurial fungicide does not evaporate or leak out or crystallise out of the paint film on exposure and is stated to remain effective for the service life of the paint.

GAS TURBINE TECHNOLOGY COURSES.—We have received details of the 1955 syllabus arranged by the School of Gas Turbine Technology, Farnborough Place, Farnborough, Hants. The courses in the programme, which start on March 7th, range from one week to three weeks' duration, accommodation being provided. A practical aero-engine course is repeated five times during the year. It is concerned with stripping, assembly and constructional details and does not require a high standard of academic knowledge. This course lasts two weeks. All the other courses are concerned with the theory and design of gas turbines. An international course on aero and industrial gas turbines is of fourteen days' duration and is repeated once ; an aero-engine design course lasting three weeks is repeated twice. Three separate courses, each of one week's duration, are provided on the theory and design of compressors, of turbines and of combustion and heat exchangers. These run consecutively and the group is not repeated. Finally there is a three-week course on the design and application of industrial gas turbines, which is repeated once. All the design courses are of post-graduate standard. They include the running and testing of engines together with performance calculations. The industrial design courses also include specialist lectures on economics and on the use of gas turbines for power generation, ship propulsion, land traction and process plant installations. The international courses are a combination of the aero and industrial design courses. Tuition fees range from 25 to 60 guineas and an additional fee of 5 guineas per week is made for accommodation.

British Patent Specifications

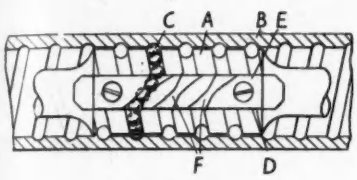
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

POWER TRANSMISSION

721,833. September 1, 1951.—Screw and Nut Mechanism, The Daimler Company, Ltd., Daimler Works, Coventry. (*Inventor: Sydney Herbert Shellard.*)

In the drawing the mechanism is shown applied to a screw and nut steering gear in which a screw *A* in the form of a shaft is mounted for axial movement within the cylindrical bore of a rotatable but axially confined nut *B* disposed about the shaft. Relative movement between the nut and screw is effected through the medium of balls *C* engaged in helical grooves in the nut and in the screw, only one series

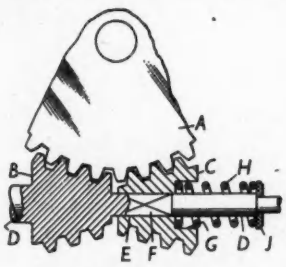


No. 721,833

of balls being shown in the drawing. Extending over the entire length of the shaft is a peripheral slot *D* with an insert *E* in the form of a plate, secured by screws. In its mounted position on the shaft the plate lies flush with the surface of the enlarged cylindrical part and substantially normal to the helical groove. The plate has formed on the outer face a series of suitable grooves or channels *F* constituting transfer passages extending substantially diagonally across the width, the distance between the ends of the respective grooves opening on each longitudinal side of the plate being equal to the pitch of the helical groove formed on the enlarged cylindrical part of the shaft. These grooves exceed in depth the diameter of the balls *C* and may be of the form shown or may conform to the transfer passages connecting the ends of each helical shaft groove as disclosed in Patent Specification No. 686,319, and preferably include the feature of canting the leading edge of each transfer port to ensure a free circulation and running of the balls. It will be appreciated that although a continuous helical groove is formed on the screw member, it is transformed into a series of axially spaced grooves consisting of one convolution or helix turn on fitment of the plate, the respective ends of the grooves produced in the screw member by the peripheral slot to receive the plate being joined to form a series of single helix turns and transfer passages by the grooves or slots in the plate.—*January* 12, 1955.

721,930. September 18, 1952.—Worm Gearing, The National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Harry Shaw.*)

In the drawing a worm wheel *A* is engaged by a worm which is divided into two parts *B* and *C*.



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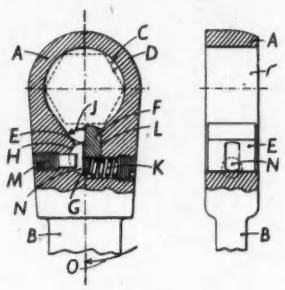
The two parts of the worm are tapered or conical and have their smaller ends adjacent to one another. The part *B* is formed integrally with or is secured to a shaft *D*. The second part *C* of the worm has a square hole *E*, which receives a squared portion *F* of the shaft *D* to provide a slidable connection. The outer or larger end of the worm part *C* is counterbored at *G* to form a seating for one end of a coiled compression spring *H*. The other end of the spring bears against a plate *J* secured to the shaft. The spring presses the part *C* towards the part *B* of the worm, taking up any clearance between the worm and worm wheel teeth and so tending to eliminate backlash. In a modification adjustments to counteract wear by means of an adjusting screw arrangement in place of a spring are also mentioned.—*January* 12, 1955.

TOOLS AND WORKSHOP APPLIANCES

721,476. March 28, 1952.—Ratchet Spanners, Regie Nationale Des Usines Renault, 8-10, Avenue Emile Zola, Billancourt (Seine), France.

Referring to the drawing, it will be seen that the spanner is formed by a head *A* having an operating handle *B*. The lever is provided with a cylindrical aperture *C*, which engages over the nut *D*. A pawl *E* has a tip *F* which acts on the faces of the nut, and has a body *G* which pivots in a cylindrical recess *H* in the spanner. This pawl can be moved in the direction of the arrow *J* against the action of a spring *K* mounted in a recess in the spanner, which spring urges it constantly against the inside face *L* of the



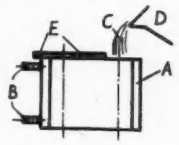
No. 721,476

recess *H* holding the pawl. A screw *M*, the end of which is housed in a slot *N* in the body *G* of the pawl, prevents it from moving laterally. Operation is as follows: the nut *D* to be tightened being engaged by the spanner, if the latter is moved in the direction of the arrow *O* the tip *F* of the pawl is jammed against the face of the hexagon, thus rotating the nut. In order to release the spanner and return it for a further tightening operation, it is sufficient to move it in the opposite direction to the arrow *O*, the pawl, pivoting about the axis and compressing the spring *K*, slides on the nut face. When the spanner is brought to rest, the pawl under the thrust of the spring resumes its original position and the spanner can be used for further tightening.—*January* 5, 1955.

METALLURGY

720,065. August 8, 1952.—A Method of Continuous Casting, Gebr. Böhler and Co. Aktiengesellschaft, Elisabethstrasse 12, Vienna 1, Austria.

According to the invention the formation of flaws during the continuous process of casting billets, especially of long cross-sections, from high-melting point metals or their alloys is prevented by furnishing some heat-resisting material for covering at least half of the upper opening of the mould. The drawing shows a chill-mould *A*, open at both ends, into which the cooling agent is admitted by means of pipes *B*. The molten metal is poured into the mould as a freely falling spray *C* from a ladle *D*. To prevent the appearance of flaws, which are likely to be formed at the end of the mould's wall remote from the end, at which the spray is situated, a great deal of the upper opening is covered by a plate of refractory material *E*. This procedure involves simple, convenient handling and, moreover, effects a decrease of the oxygen content in the supernatant atmosphere during the continuous casting process and thus causes it to act almost like an inert gas-atmosphere. Another advantage involved is the reduction of heat radiation, so that the procedure of casting can be performed more smoothly.—*December* 15, 1954.

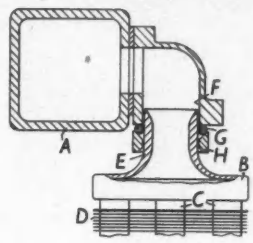


No. 720,065

HEAT EXCHANGERS

721,691. March 11, 1952.—Heat Exchanger Connections, Serck Radiators, Ltd., Warwick Road, Greet, Birmingham, 11. (*Inventor: Albert Fowler.*)

The invention relates to heat exchangers of the kind in which a stream of air flowing over tubes is utilised for cooling a liquid such as oil or water flowing through the tubes, and particularly a heat exchanger in which a tubular unit or a number of tubular units are mounted parallel with each other between a pair of headers. Referring to the drawing, a pair of upper and lower headers as *A* are arranged parallel with each other, the upper one only being shown in the drawing. Between them are mounted the tubular units in parallel with each other. Each unit comprises a pair of upper and lower headers *B* interconnected by tubes *C* provided with gills or inserted through thin metal plates *D* serving as secondary heat-conducting surfaces. The header *B* of each of the tubular units is connected to the adjacent common header *A* by a spigot *E* entering a socket *F*, the spigot being telescopically slidable relatively to the socket.



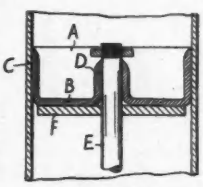
No. 721,691

Also a fluid-tight seal is provided by a rubber ring *G*. Each socket is in the form of an elbow attached to one side of the header *A*, and the spigot is attached to and extends vertically from the header of the associated tubular unit. The ring *G* is secured by a part *H* on the spigot and attached by screws. By the invention each tubular unit is free to expand or contract independently of the others, and injurious straining of any unit due to unequal relative expansions or contractions is reduced or obviated.—*January* 12, 1955.

BLOWERS AND COMPRESSORS

720,105. December 24, 1951.—Fluid Sealing Means, William Turner, 44, Eyre Lane, Sheffield, 1.

Referring to the drawing, the "cup-leather" *A* is formed of heat-resisting material and comprises a disc *B* having an outer peripheral flange *C* and an inner concentric flange *D* surrounding the central aperture of the disc, both flanges being in parallel with one another at right angles to one face of the disc *B*. The "cup-leather" is mounted by its central aperture upon the piston rod *E* between a pair of annular abutments one of which is constituted by the piston back plate *F* and the other by a nut screwed on to the end of the piston rod, the arrangement being such that the "cup-leather" is allowed a slight axial play. In use, although the "cup-leather" is permitted a slight axial play on the piston rod it will function in substantially the same manner, and as efficiently as a normal "cup-leather," and on the operative stroke, which is in an upward direction as shown in the drawing, the fluid being compressed in the cylinder forces the two concentric flanges into engagement respectively with the wall of the cylinder and the surface of the piston rod so as to prevent escape of the fluid. Whilst on the return stroke, the pressure of fluid behind the piston tends to force the concentric flanges *C* and *D* away from their engagement with the wall of the cylinder and the surface of the piston *E*. A modified design is also shown in the specification.—*December* 15, 1954.

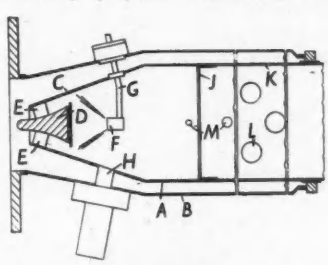


No. 720,105

GAS TURBINES

721,899. March 6, 1952.—Liquid Fuel Combustion Apparatus, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventors: Eric Samuel Collinson and John Clegg.*)

The invention relates to liquid fuel combustion apparatus for jet propulsion engines or gas turbines,



No. 721,899

the object being to enable complete combustion of the fuel to be effected at a rapid rate. Referring to the drawing, the cylindrical sheet metal combustion

chamber *A* is surrounded by an air jacket *B*, to which air is supplied by an axial pipe from a blower. The entrance end *C* of the combustion chamber is of truncated conical form, and in the smaller end is mounted an axially arranged conical plug *D*, which causes the incoming air from the pipe to flow into the combustion zone in the form of an annular stream directed towards the peripheral wall of the combustion chamber. If desired, swirl vanes *E* may be provided in the annular passage around the plug. In the combustion chamber there is mounted on the axis of the chamber a liquid fuel nozzle *F*, carried by a fuel supply pipe *G*, and which discharges the fuel in the upstream direction in the form of a hollow conical jet which impinges on the incoming annular air stream. For igniting the fuel-air mixture ignition means is provided at the part *H*. At the exit end of the combustion chamber there is mounted an annular baffle *J* in the path of the air stream to set up a swirling motion in the ignited fuel-air mixture. On emerging through the centre of the baffle the hot gases enter a flame tube *K* which consists of a cylindrical extension of the combustion chamber. Diluent air is admitted to the flame tube from the air jacket through orifices *L* in the flame tube. Air is also admitted from the jacket through orifices *M* situated adjacent to the baffle. A combustion chamber of annular form is also described in the specification.—*January* 12, 1955.

Launches and Trial Trips

IPHIGENIA, oil tanker ; built by the Chantiers de la Ciotat for the Société Maritime Shell ; length overall 553ft 5in, length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 35ft, deadweight 18,300 tons, service speed 14½ knots ; two 550kW turbo-alternators, one 200kW diesel-driven generator ; one set of Parsons geared turbines built by the Forges et Chantiers de la Mediterranee, 7500 s.h.p. at 100 r.p.m. of propeller. Trial, December.

MARCEL MOUNIER, tanker ; built by the Chantiers Navals de la Pallice ; length overall 287ft 2in, length between perpendiculars 262ft 6in, breadth moulded 40ft 8in, depth moulded 19ft, draught loaded 16ft 5in, displacement 3500 tons, deadweight 2150 tons, service speed 13 knots ; twenty tanks for vegetable oil or wine ; two 55kW steam-driven generators, two 55kW diesel generators ; M.A.N. oil engine of 2000 h.p. at 225 r.p.m., built by Ateliers et Chantiers de Bretagne. Trial, December.

IRMA, cargo ship ; built by Alexander Stephen and Sons, Ltd., for Det Bergenske Dampskibsselskab, Norway ; length 400ft, breadth 57ft, depth 35ft, load draught 23ft, gross tonnage 4550, deadweight 6530 tons ; twelve passengers ; seven watertight bulkheads, five cargo holds, complement of 3-ton, 5-ton and 10-ton derricks and one 30-ton derrick ; three 180kW diesel-driven generators ; Stephen-Doxford opposed piston, two-cycle oil engine, four cylinders 670mm diameter by 2320mm combined stroke, service speed 14½ knots. Trial, December.

CEDARBANK, cargo ship ; built at the Belfast yard of Harland and Wolff, Ltd., for the Andrew Weir Shipping and Trading Company, Ltd.; length overall 450ft, length between perpendiculars 425ft, breadth moulded 59ft, depth moulded to shelter deck 38ft 3in, gross tonnage 5671 ; two complete steel decks, seven watertight bulkheads, four main cargo holds, two 3-ton, fourteen 5-ton and one 25-ton derricks ; Harland and Wolff two-stroke, single-acting, opposed piston diesel engine, six cylinders 620mm diameter by 1870mm combined stroke ; three 175kW diesel-driven generators. Trial, January 5th.

CAPETAN PSARROS, cargo liner ; built at the Neptune yard of Swan, Hunter and Wigham Richardson, Ltd., for the Tramp Chartering Corporation of Panama ; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to shelter deck 40ft 4in ; derrick complement includes one to lift 20 tons and one to lift 30 tons ; three 180kW diesel-driven generators, one 50kW diesel-driven generator ; Swan, Hunter-Doxford oil engine, five cylinders 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m. Launch, January 7th.

SIR JOHN SNELL, self-trimming collier ; built by Hall Russell and Co., Ltd., for the British Electricity Authority ; length between perpendiculars 323ft, breadth moulded 43ft 3in, depth moulded 20ft 3in/25ft 9in ; four holds, steam deck machinery ; one direct-acting triple-expansion "North Eastern Reheat" steam engine, built by the North Eastern Marine Engineering Company, Ltd., 1475 i.h.p., steam supplied at 220 lb per square inch by two oil-fired cylindrical boilers. Launch, January 11th.

LOUDIMA, cargo ship ; built by the Ateliers et Chantiers de la Loire for the Compagnie Maritime des Chargeurs Reunis ; length overall 428ft 6in, length between perpendiculars 399ft 8in, breadth moulded 55ft 9in, depth to shelter deck 35ft 1in, draught loaded 24ft 1in, displacement 10,940 tons, deadweight 7220 tons, speed 15·3 knots ; two 240kW diesel-driven generators ; Sulzer two-stroke, single-acting, diesel engine, eight cylinders 720mm diameter by 1250mm stroke, 5000 b.h.p. at 120 r.p.m. Trial, January.

BOREE, cargo ship ; built by the Ateliers et Chantiers de Bretagne for the Société Navale Caennaise ; length overall 296ft 11in, length between perpendiculars 277ft 3in, breadth moulded 43ft 8in, depth 23ft 8in/26ft 3in, draught 19ft 8in, deadweight 2350 tons, service speed 17 knots ; three holds, four 5-ton, two 10-ton derricks, electric deck machinery ; three 80kW diesel-driven generators ; two S.E.M.T.-Pielstick diesel engines of 1500 h.p. at 425 r.p.m. drive single propeller at 200 r.p.m. through couplings. Trial, January.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BELFAST ASSOCIATION OF ENGINEERS

Wed., Feb. 9th.—The College of Technology, Belfast, "The History and Development of Mine Ventilation," L. Irwin, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 9th.—WEST MIDLANDS SECTION : Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton, "Electronic Motor Control Systems," J. C. Rankin, 7.15 p.m.

Thurs., Feb. 10th.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Radio Telephone Systems to the Islands," T. Moxon, 7 p.m.

CHEMICAL SOCIETY

Thurs., Feb. 10th.—BRISTOL BRANCH : The University, Bristol, "Some Newer Aspects of the Organic Chemistry of Nitrogen," G. R. Clemo, 7 p.m.

Fri., Feb. 11th.—NEWCASTLE AND DURHAM BRANCH : Chemistry Building, King's College, Newcastle upon Tyne, "The Place of Theoretical Chemistry in Chemical Education," R. P. Bell, 5.30 p.m.——ST. ANDREWS AND DUNDEE BRANCH : Chemistry Department, The University, St. Andrews, "The Organic Chemistry of Phosphorus," H. N. Rydon, 5.15 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Feb. 8th.—Hull Church Institute, Hull, "The History of the Typewriter," R. M. Evans, 7.30 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Feb. 8th.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, "Foundations for Buildings and Machinery," A. Mason, 7 p.m.——MANCHESTER BRANCH : The Engineers' Club, Albert Square, Manchester, "Electronic Control in Industry," J. E. Fielden, 7.15 p.m.

Wed., Feb. 9th.—EAST MIDLANDS BRANCH : Adult Education Centre, Shakespeare Street, Nottingham, "Changing Bad Ions for Good," F. C. H. Taylor, 7 p.m.

Thurs., Feb. 10th.—NORTH-EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Fuel Injection Equipment," H. J. Stoneman, 7 p.m.

Fri., Feb. 11th.—BIRMINGHAM BRANCH : Imperial Hotel, Birmingham, Annual Dinner.

INSTITUTE OF BRITISH FOUNDRYMEN

Sat., Feb. 5th.—LANCASHIRE BRANCH : The Engineers' Club, Albert Square, Manchester, "Aluminium Casting Alloys," R. Mercer, 3 p.m.

Sat., Feb. 12th.—NEWCASTLE BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Production of Heavy Steel Castings," S. Taylor, 6 p.m.——SCOTTISH BRANCH : Royal Technical College, Glasgow, "Some Aspects on Steel Foundry Practice," H. Hart, 3 p.m.

INSTITUTE OF FUEL

To-day, Feb. 4th.—S. WALES SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, "Smoke Abatement," A. C. Monkhouse, 6 p.m.

Thurs., Feb. 10th.—Institution of Civil Engineers, Great George Street, London, S.W.1, "Wales Gas Board : Integration of Fuel Supplies," E. M. Edwards, W. T. Hird, S. L. Wright, and T. S. Ricketts, 5.30 p.m.

Fri., Feb. 11th.—EAST MIDLAND SECTION : The "Black Boy," Nottingham, Annual Dinner, 7 p.m.

Mon., Feb. 14th.—NORTH-EASTERN SECTION : Chemistry Lecture Theatre, King's College, Newcastle upon Tyne, Students' Evening, 6.30 p.m.

Wed., Feb. 16th.—YORKSHIRE SECTION : Hotel Metropole, Leeds, "An Approach to Fuel Economy in a Large Engineering Works," F. A. Worsley, 2.30 p.m.

INSTITUTE OF METALS

Tues., Feb. 8th.—SOUTH WALES LOCAL SECTION : Metallurgy Department, University College, Singleton Park, Swansea, "Tool and Die Steels," E. Johnson, 6.45 p.m.

Mon., Feb. 14th.—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, "Some New Developments in Nickel Alloys," A. B. Graham and C. C. Horne, 6.30 p.m.

Wed., Feb. 16th.—Birmingham University, Edgbaston, Birmingham, Informal Discussion on "Non-Metallic Die Materials."

INSTITUTE OF PETROLEUM

Wed., Feb. 9th.—26, Portland Place, London, W.1, "Applicational Research in the Petroleum Industry," C. G. Williams, 5.30 p.m.

Mon., Feb. 21st.—26, Portland Place, London, W.1, "The Modern Planning of Regional Surveys for Petroleum," P. Leicester, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Feb. 7th.—N.W. CENTRE : Engineers' Club, Albert Square, Manchester, "The Port of Manchester," P. N. Reed, 7.30 p.m.

Tues., Feb. 8th.—MIDLANDS CENTRE : Crown Inn, Broad Street, Birmingham, "Road and Rig Testing of Prototype Road, Transport Vehicles and Their Components," J. Alden, 7.30 p.m.

Wed., Feb. 9th.—WESTERN CENTRE : Grand Hotel, Bristol, "Paint : Synthetic Resin Finishes and Wet-on-Wet Spraying," C. Butler, 7.30 p.m.

Thurs., Feb. 10th.—EAST MIDLANDS CENTRE : The Mechanics' Institute, Nottingham, "Roads and Commercial Transport," Dr. G. Charlesworth, 7.30 p.m.——SOUTH WALES GROUP : South Wales Institute of Engineers, Park Place, Cardiff, "Plastics and their Use in the Road Transport Industry," A. Jones, 7 p.m.

INSTITUTE OF THE MOTOR INDUSTRY

Tues., Feb. 8th.—40, Queen's Gate, London, S.W.7, "Automotive Products Manumatic Gear Control," J. St. H. Webb, 7.30 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Feb. 8th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Effects of Mechanical Treatment on the Drying Rate of Hay in the Field," F. S. Mitchell and G. Shepperson, 2.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Feb. 8th.—The Geological Society, Burlington House, London, W.1, "The Mechanism of Drying of Solids," E. W. Bruce, R. F. Strickland-Constable, and D. M. Newitt, 5.30 p.m.

Wed., Feb. 9th.—NORTH-WESTERN BRANCH : The Grosvenor Hotel, Chester, "Minimum Reflux Conditions for Multiple-Feed Columns," N. L. Franklin, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 8th.—Great George Street, London, S.W.1, "The Effect of 'Storage' on Sewerage Design," C. D. C. Braine, 5.30 p.m.

Thurs., Feb. 10th.—BIRMINGHAM BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, "Shuttering and Concrete," S. G. Boosie, 6 p.m.

Mon., Feb. 14th.—NORTH-WESTERN ASSOCIATION : Reynolds Hall, College of Technology, Manchester, "The Process Building at Capenhurst : Some Structural Problems," T. C. Waters, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Feb. 7th.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "The Problem of Radio Interference," opened by C. W. Sowton, 5.30 p.m.

Wed., Feb. 9th.—Savoy Place, London, W.C.2, "A Study of Commercial Time Lost on Transatlantic Radio Circuits Due to Disturbed Ionospheric Conditions," J. K. S. Jowett, 5.30 p.m.

Thurs., Feb. 10th.—Savoy Place, London, W.C.2, "Maintenance Principles for Automatic Telephone Exchange Plant," R. W. Palmer, 5.30 p.m.——DUNDEE BRANCH : Queen's College, Dundee, "The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems," D. P. Sayers, 7 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Feb. 7th.—NORTH-EAST BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Modern Turbo-Alternators," P. Richardson, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 8th.—39, Elmbank Crescent, Glasgow, "Paddle Wheel Research," H. Volpich, 7.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Feb. 9th.—St. Bride Institute, Bride Lane, London, E.C.4, "The Automotive Diesel Engine and its Applications," A. W. Gosling, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 7th.—MERSEYSIDE AND NORTH-WESTERN SECTION : The Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "Some Observations on Marine Gearing," J. Rogerson, 6.30 p.m.

Tues., Feb. 8th.—85, Minories, London, E.C.3, "Practical Approach to Some Vibration Problems in Ships," T. W. Bunyan, 5.30 p.m.

Wed., Feb. 9th.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, 7.30 p.m., followed by a Lecture at 7.45 p.m., "The Design and Construction of a 10,000-Ton Cargo Ship," J. Baird.

Thurs., Feb. 10th.—WEST MIDLANDS SECTION : Imperial Hotel, Birmingham, Annual General Meeting, 6.45 p.m., followed by a Lecture at 7.30 p.m., "Design and Operation of Nuclear Power Stations," H. S. Arms.——MERSEYSIDE AND NORTH-WESTERN SECTION : Bolton Technical College, Bolton, "Auxiliaries," P. Scorer, 3 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 4th.—AUTOMOBILE DIVISION : Dorchester Hotel, London, W.1, Dinner and Dance, 7 p.m.

Mon., Feb. 7th.—NORTH-EASTERN BRANCH : Neville Hall, Newcastle upon Tyne, General Meeting, Thomas Lowe Gray Lecture, Cdr. (E.) L. Baker, 6 p.m.

Tues., Feb. 8th.—AUTOMOBILE DIVISION GENERAL MEETING : 1, Birdcage Walk, Westminster, S.W.1, "The Running-in of Engines : Choice of Cylinder Bore Finish," K. R. Williams and S. G. Daniel, 5.30 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Welding and Fabrication," F. G. C. Sandiford, 7 p.m.

Wed., Feb. 9th.—NORTH-WESTERN BRANCH : The Temple, 24, Dale Street, Liverpool, "Some Factors in the Selection of Machinery for Cargo Liners," Cdr. (E.) L. Baker, 6 p.m.——SOUTHERN BRANCH : Transport Equipment (Thornycroft), Ltd., Basingstoke, Hants, "Some Problems in Lubrication and the Substances Called Additives," A. Towle, 7.30 p.m.

Thurs., Feb. 10th.—YORKSHIRE BRANCH : The University, Leeds, "Design and Development of the Rolls-Royce 'RM 60' Marine Gas Turbine," A. Holmes Fletcher and R. W. Corbett, 6.30 p.m.——1, Birdcage Walk, Westminster, London, S.W.1, "Disc Brakes Applied to Road Vehicles," J. O. Starling, 6.30 p.m.——SOUTHERN SECTION : Royal Aircraft Establishment, Technical College, Farnborough, "Suspension Systems for the Modern Sports Car," J. M. Frankham, 7.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Feb. 8th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, "Depreciation and Service Life of Telecommunications Equipment," N. V. Knight, 5 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., Feb. 10th.—11, Upper Belgrave Street, London, S.W.1, "Structural Prestressing," F. J. Samuely, 5.55 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 7th.—N.E. BRANCH: Neville Hall, Mining Institute, Neville Street, Newcastle upon Tyne, "Rubber Machinery," K. Bradshaw, 7 p.m.——BURTON-ON-TRENT BRANCH : Midland Hotel, Station Street, Burton-on-Trent, "Rubber-Based Adhesives," A. A. Round, 7.15 p.m.

Tues., Feb. 8th.—Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Some Practical Aspects of Automatic Control in the Rubber Industry," E. R. Amery, 5.30 p.m., followed at 7 p.m. by "Properties of Whiting and Other Calcium Carbonates Used as Fillers in Rubber," G. E. Bessey.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 4th.—FILM EVENING : Pepys House, 14, Rochester Row, London, S.W.1, "Industrial Shunting," and "Maritime Progress," 7 p.m.

Fri., Feb. 11th.—Pepys House, 14, Rochester Row, London, S.W.1, "Underground Water," K. G. Bewham, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Feb. 10th.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Thermochemistry of Alloys," A. R. Harding, 7 p.m.

LONDON ASSOCIATION OF ENGINEERS

Sat., Feb. 5th.—Alliance Hall, Palmer Street, London, S.W.1, "Transport in A.D. 2000," E. W. Chalmers-Kearney, 6.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 4th.—Engineers' Club, Albert Square, Manchester, "Some Problems Associated with the Selection of Machine Tools for Heavy Engineering Production," J. Henderson, 6.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 8th.—4, Hamilton Place, London, W.1, "Some Trends in the Development of Aircraft Electrical and Starting Systems," R. H. Woodall, 7 p.m.

Thurs., Feb. 10th.—Saunders-Roe Club House, Cowes, I.O.W., "Problems and Prospects of Rocket Propulsion for Aircraft," A. D. Baxter, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Feb. 7th.—12, Great George Street, London, S.W.1, "Roman London," W. F. Grimes, 5.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 9th.—John Adam Street, Adelphi, London, W.C.2, "Public Lettering," C. Barman, 2.30 p.m.